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Plant performance on surface coal mine spoil in Eastern United States

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Preface

The Soil Conservation Service operates plant materials centers where plant specialists assemble, evaluate, select, and release for commercial production plants for specific conservation uses. SCS early recognized the need for plants to stabilize surface mine spoil. Joseph D. Ruffner, who worked as SCS plant materials specialist in the Northeast until his retirement in 1974, was a leader in the SCS search for suitable plants. This report, prepared by Mr. Ruffner, summarizes SCS evaluations of plant performance on coal mine spoil in Eastern United States from 1946 to 1976.

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Introduction

Surface mining in Eastern United States disrupts sites to the extent that the original plant communities are poorly adapted to the new conditions. Because revegetation of surface mine spoil is essential for environmental reasons and is frequently mandated by state and federal laws, the Soil Conservation Service has assembled, evaluated, and screened many native and introduced species in an effort to find adapted plants primarily for erosion control.

Small plantings have been made under controlled conditions throughout the eastern coal mining region since 1946. Outstanding species have been tested in large field plantings to confirm their adaptation and performance (24).

A variety of plant assemblies was tested for tolerance to mine spoil conditions. Priority was given to plants that have low maintenance requirements, such as those that fix nitrogen or tolerate acidity and low fertility. Through comparative evaluations, some plants were selected for widespread use and some were eliminated as unsuitable. Others were found to be effective only in restricted climatic zones or on spoils that have specific characteristics.

Source of data

This report summarizes the results of SCS plant evaluations from all states in the eastern coal mining region, including data from field planting plans and annual reports of SCS plant materials centers. All species tested in SCS plantings are listed in tables 1 through 5. Species that have widespread use or are best suited to special uses are discussed in the text. Information on special cultural and management practices required for a given species or site condition is also given in the text.

The data in the tables are field observations from SCS plantings and plantings conducted cooperatively with state agencies and other federal agencies. The text includes information from these plantings and from studies of plant performance in which SCS did not participate. These sources are listed in the References at the end of this report and cited by numbers in parentheses in the text.

Characteristics of mine spoil in the eastern coal mining region

Much of the coal mine spoil in this region contains no organic matter or soil microorganisms and little or no nitrogen. The surface layer of graded spoil consists of rock fragments and soil particles of silt, sand, and clay. Channels for percolation of water generally are not well developed, and the bare surface often becomes extremely hot in summer. Toxic salts of iron, aluminum, copper, and manganese commonly occur in amounts detrimental to plant growth. Oxidation of sulfur may lower the spoil pH to a toxic level. Acid spoil is particularly low in available phosphorus, which restricts the growth of most plants.

Grading methods used in mining operations vary considerably, and some add to the problem of establishing cover. Long, steep slopes erode rapidly, spoil compaction restricts root development, and placing very

acid or toxic spoil on the surface impairs plant growth (see figure 1).

Grading that produces gentle slopes helps to increase rainfall absorption and reduce runoff. On gentle slopes, more water infiltrates the spoil and leaches toxic salts from the surface layer, more moisture is available for plant growth, and erosion is reduced. Placing fertile overburden on the surface also benefits plant growth.

Classification of coal mine spoil

To project results based on test plantings to other areas, plant performance must be correlated with site conditions and climate.

Major spoil characteristics that affect plant growth and influence planting and management techniques include reaction, texture, degree of stoniness, slope, and fertility. Surface mine spoil was not being surveyed or systematically classified at the time these plant studies were conducted. To be better able to interpret, correlate, and project results, it was necessary to group the spoils based on a dominant characteristic. Because the degree of acidity has been identified as the factor most affecting plant performance in the eastern coal mining region, spoils were grouped according to reaction as follows:

Spoil group	*Reaction*
Slightly acid (SA)	pH 5.5 and above
Acid (A)	pH 4.0 to 5.4
Very acid (VA)	below pH 4.0

At present a new system for classifying mine spoil is under study and is being evaluated for incorporation into the National Cooperative Soil Survey. Many plots used in testing plant performance for this report were surveyed and classified according to this new system. All data on test plot profile descriptions are in the files of the SCS Northeast Technical Service Center.

Figure 1.—Bare and eroding steep outer slopes and compacted level spoil are typical of early strip mine spoil.

Land resource areas (LRA's)

Major land resource areas (LRA's) are used in the evaluation of plant performance. A map and descriptions of LRA's are in a section at the end of this report. The performance of some plant species on surface mine spoil varied considerably between the northern and southern parts of LRA's 126 and 127. These two LRA's are divided into northern and southern subareas and plant performance is rated for each subarea. The dividing line is the Mason-Dixon line and an extension of it into Ohio.

Selection of sites for test plots

Sites for test plots were usually selected 3 to 6 months after the mine spoil was graded to meet specifications required by law. The following method of site selection was used:

1) A determination was made as to which spoil groups should be represented in test plots within each LRA. For example, the pH of mine spoil in LRA 127 ranged below 4.0 to above 5.5. Therefore sites representing each of the spoil groups (SA, A, VA) were used in test plots.

2) Sites typical of the spoil topography resulting from the most commonly used mining method and representing the dominant spoil groups also were selected. For example, in LRA 127 contour mining was most common.

Therefore sites representing each spoil group were located on the bench and outer slope.

The pH of test plots was monitored after planting. If the pH changed significantly, observations on plant performance were adjusted accordingly.

Performance ratings of individual plant species

Plant performance is reported in both tables and text. Tables 1 through 5 provide information on all species evaluated by the Soil Conservation Service over the past 30 years. The tables give plant performance of each species as compared with other species within each plant group. The criteria used to rate plant performance vary with each plant group and are explained in the performance code for each table.

Plantings in LRA's 128, 140, and 147 were limited in number and extent. Consequently, data from plantings in LRA 128 were grouped in the tables with LRA 127S. Data from plantings in LRA's 140 and 147 were grouped in the tables with LRA 127N. Although data from plantings in LRA's 128, 140, and 147 are not shown separately in the tables, significant information on performance of individual species in those LRA's is included in the text.

The text provides information about the most commonly used species and about other species that appear promising for use on mine spoil, including site adaptation, site requirements, relative performance between species, yield data, requirements for establishment, and restrictions on use. The text also includes performance data provided by non-SCS sources.

Throughout the text, site conditions are described by reference to three factors: 1) climate (according to LRA); 2) spoil group (SA, A, VA); and 3) age of the planting. It is convenient to abbreviate these conditions as shown in the following examples:

120-SA-10——the planting is in LRA 120, the spoil is slightly acid (pH 5.5 and above), and the planting is 10 years old.

127N-A-5——the planting is in the northern part of LRA 127, the spoil is acid (pH 4.0 to 5.4), and the planting is 5 years old.

Many species listed in the tables are not discussed in the text because they failed to establish or survive, their performance suggested they had little or no potential for use in mine spoil stabilization, or the available data on their performance were inconclusive or insufficient to warrant discussion.

Plant names

An index to all species is at the back of this report. The index gives the scientific name, the common name, the page in the text where the plant is discussed, and the table in which performance data are given.

The principal source of scientific plant names used in this summary was the *National List of Scientific Plant Names* prepared by the Soil Conservation Service. For species names not found in that list, the following references were used:

Bailey, L. H. 1976. Hortus Third. The MacMillan Company, New York.

Britton, N., and Brown, A. 1936. Illustrated Flora of the Northern United States and Canada. New York Botanical Garden, New York.

Fernald, M. L. 1950. Gray's Manual of Botany. American Book Company, New York.

Gleason, H. A., and Cronquist, A. 1963. Manual of Vascular Plants of the Northeastern United States and Adjacent Canada. G. Van Nostrand Co., Inc., Princeton, New Jersey.

Hitchcock, A. S. 1950. Manual of the Grasses of the United States, 2d ed. Rev. by Agnes Chase. USDA Misc. Publ. 200.

Little, E. L., Jr. 1953. Checklist of Native and Naturalized Trees of the United States (including Alaska). USDA Handb. 41.

Small, J. K. 1933. Manual of the Southeastern Flora. Science Press Printing Company, Lancaster, Pennsylvania.

Common names of plants are not systematized. Different plants often have the same common name or the same plant may have different names. References on common names disagree on spelling, capitalization, hyphenation, etc. The common names used in this report are from the foregoing references. If none of these provided a common name, the following was used:

Kelsey, H. P., and Dayton, W. A. 1942. Standardized Plant Names, 2d ed., rev. J. Horace McFarland Company, Harrisburg, Pennsylvania.

In some cases no common names were found. Cultivars are identified by single quotation marks.

Woody species

Procedure for field testing

Survival, vigor, and growth rate are characteristics that best describe performance of woody species on mine spoil. To assess performance using these criteria requires a large number of plantings, each containing many plants. The number of plants used and the range of site conditions were sufficient to provide a good basis for the evaluations reported here. Records of conditions at the time of planting and followup reports provided adequate data for detecting and eliminating unusual site and planting conditions.

In most SCS evaluation plantings, species or accessions of unknown performance were planted, for comparison, next to species of known performance. In each planting 50 to 100 plants of each species or accession were planted in plots consisting of two to four rows. Plots were laid out so as to be representative of the site, including steep outer slopes and nearly level benches.

Spacing between rows and between plants within the rows was usually 6 to 7 feet. In some cases this close spacing created an edge effect and caused either suppression or increased vigor between certain species. In West Virginia for example, purpleosier willow increased in height at a greater rate when planted next to European black alder than when planted next to a species that does not fix nitrogen. Allowances for such variations have been made in performance ratings.

Trees

Table 1 gives performance ratings for trees. Species that were tested most widely are discussed in the following text. Growth rate of trees is given in the text as, for example, 4 inches by 15 feet, which indicates the diameter of the plant in inches at a height of about 5 feet and the total height of the plant in feet.

Acer rubrum, red maple

This species was tested in most LRA's, but not in sufficient numbers to confirm its role as a plant useful in mine spoil reclamation. In general, survival was below the average for other hardwood tree species but growth was fair to good in open stands. Quality planting stock was not available, which may explain the poor survival rate. Red maple volunteers on spoil in LRA 127 but the plants are not nearly as vigorous as volunteer eastern cottonwood. Recorded performance in 1975 was: 120-A-17—1.5 inches by 15 feet and 125-A-7 —1.0 inch by 8 feet.

Acer saccharinum, silver maple

In LRA's 114, 120, and 124, silver maple is well adapted to slightly acid spoil. In Illinois, a survival rate of 61 percent was reported (14). Because of its good performance, silver maple is currently planted by coal mining companies in Illinois, Indiana, and Ohio in mixtures with sycamore, sweetgum, ash, and red oak. Performance compared to other species is shown below:

Species	*120-SA-13*	*124-SA-10*	*125-A-10*
European black alder	4 in x 25 ft	4 in x 20 ft	———
silver maple	4 in x 28 ft	4 in x 28 ft	3 in x 8 ft
sweetgum	3 in x 18 ft	———	4 in x 22 ft
sycamore	6 in x 35 ft	6 in x 35 ft	3 in x 25 ft
white pine	4 in x 18 ft	4 in x 20 ft	———

In Ohio, Indiana, and Illinois, increased growth was noted where silver maple was planted in mixtures with black locust. This was probably due to the nitrogen-fixing ability of black locust.

Ailanthus altissima, ailanthus or tree of heaven

This species was not planted extensively. Performance was poor in LRA's 125, 126, and 127. Some plants reached a height of 8 feet in 8 years, but growth was steadily declining and survival was poor.

Albizia julibrissin, silktree or mimosa

Ten-year-old plantings in Kentucky (125-A-10) were 20 feet high with a crown spread of

20 to 25 feet. Diameter at 1 foot above ground level was 6 to 8 inches. Survival was estimated at 80 percent, and vigor was excellent. In Tennessee (LRA 128), two SCS plantings on very acid and acid (pH 5.0) spoil failed.

Alnus glutinosa, European black alder
Alnus incana, speckled alder

Both are nitrogen-fixing hardwood trees not to be confused with the native shrub alders. Both are outstanding for their tolerance of very acid spoil of pH 3.5 and for their vigorous juvenile growth (15). Survival rates have been as good or better than those of most tree species; 80 percent is common.

SCS plantings indicate European black alder is superior to speckled alder in vigor and form. European black alder may be single or multistemmed, whereas speckled alder is always multistemmed. Speckled alder frequently root suckers after the fifth year. Both species reproduce by layering when lower branches become covered with sediment at the base of steep outer slopes. Reseeding is common in older stands but is of limited significance.

The following information refers only to European black alder:

In all LRA's, with the exception of 127, European black alder is slightly inferior to black locust in stand establishment and quality of vegetative cover. Alder's ability to fix nitrogen does not appear to be as good as the locust. This is indicated by a greater invasion of herbaceous species in black locust stands as well as its more favorable effect on growth of adjacent trees. However, alder is more tolerant of very acid (pH 3.5) spoil and grows better than black locust in LRA 127N and at elevations above 2,500 feet in LRA 127S.

As alder plants develop, stands decline and dieback is common, except in LRA 127 where vigorous growth and less dieback have been observed in stands 16 years old. This is more evident in the northern part of LRA 127 and at elevations above 3,000 feet in the southern part.

In Indiana, a 4-year-old stand had trees 18 feet high, and on another site European black alder was growing on spoil of pH 3.0. The upper pH limit was 7.5.

There is considerable variation in plant performance on spoil with similar characteristics but alder grows best where soil moisture is favorable (8). This may explain why alder grows better in LRA 127 than in other LRA's.

Alder is valuable as a nurse tree because it fixes nitrogen. This has been observed repeatedly in SCS plantings. Dale (6) also reports this function.

The best use of alder is for spoils of pH 3.5 to 4.5 in all LRA's, and for any site in LRA's 127 and 147 where woody species are needed for quick vegetative cover. A spacing of 8 feet by 8 feet was adequate for steep slopes in LRA 125 (southern West Virginia). After 4 years, vegetative cover and closing of canopy at this spacing was equal to plantings spaced 6 feet by 7 feet (see figures 2 and 3). The best recorded performance of European black alder follows: 120-A-10—16 inches by 40 feet (single tree); 127S-A-16—4 inches by 30 feet (stand average); 125-A-5—2 inches by 20 feet (stand average); and 147-A-15—3 inches by 25 feet.

Figure 2.—European black alder spaced 10 feet by 10 feet closed canopy after 8 years on acid (pH 5.0) spoil in LRA 125.

Betula alleghaniensis, yellow birch
Betula lenta, sweet (black) birch
Betula populifolia, gray birch

All these plants volunteer readily on coal mine spoil but fail to establish good stands when planted as seedlings.

The best performance of sweet birch was recorded at elevations above 2,000 feet in LRA 127S, where survival was 52 percent.

Gray birch grows well on acid spoil. Survival rate is more than 60 percent, and annual growth is about 1 foot in plantings 20 to 25 years old. Gray birch is mostly multistemmed when growing on mine spoil. In the anthracite coal region of eastern Pennsylvania (LRA 147), gray birch volunteers readily on acid coal mine spoil but stands are open and provide little cover. Direct seeding of gray birch in this area has not produced satisfactory stands.

Figure 3.—European black alder in the fifth growing season on slightly acid spoil in LRA 126S. The single straight stem with many side branches is typical for the species.

Betula nigra, river birch

River birch appears to be well adapted to LRA's 120, 124, and 125. Growth in these areas is comparable to sweetgum and sycamore. In one 15-year-old planting, some regeneration was noted. The performance of river birch on two sites was: 120-SA-30—5 inches by 35 feet and 125-A-10—3.5 inches by 25 feet.

Betula papyrifera, paper birch

Several plantings observed in Kentucky (LRA 125) and southeastern Pennsylvania (LRA 126N) had good survival and vigor. None of the plantings had competition from other vegetation. The comparative performance in 126N-SA-25 was: paper birch—2.5 inches by 22 feet, gray birch—2 inches by 18 feet, and Japanese larch—3.5 inches by 30 feet.

Castanea mollissima, Chinese chestnut

All plantings were on spoils of pH 5.0 to pH 7.0. They were moderately good sites regarding spoil quality and exposure. Survival was more than 50 percent in all plantings and as high as 80 percent in some. In LRA 114, fruit was produced during the sixth year. In LRA 120, trees reached a height of 20 feet in 6 years. In LRA 126N and 127N, several plantings on acid (between pH 4.5 and 5.0) spoil were only 8 to 10 feet high after 15 years but fruit production was good.

All plantings observed in 1975 were in good, vigorous condition. In most plantings trees were spaced as much as 20 feet apart, which permitted good crown development.

Fraxinus americana, American or white ash
Fraxinus pennsylvanica, green ash

Commercial plantings in Indiana and Ohio indicate that ash grows well in mixtures with other hardwoods on slightly acid spoil. In Ohio, ash is considered an important component in hardwood mixtures. Although initial growth is slow, ash usually equals other hardwoods in about 20 years.

Limstrom and Deitschman (14) and Medvick (18) report good performance of green ash in Indiana and Illinois. A survival rate of about 86 percent was reported for plantings on all spoil groups in those states.

SCS plantings in LRA's 125, 126, and 127 were not vigorous, but survival rates were 70 to 80 percent on acid and slightly acid spoil. Most other tree species were superior to ash in those LRA's, especially on spoil with a pH of 5.5 or more.

Juglans nigra, black walnut

Because black walnut has a long tap root, seedlings are difficult to plant and survival rates are usually low. Limstrom and Deitschman (14) report a 31-percent survival rate on coal mine spoil in Illinois. More favorable site conditions may be required for walnut than are normally found on spoil. Most SCS plantings in LRA's 126S and 127S had poor height growth and survival rates. Comparative height growth on one 8-year-old planting on acid spoil of pH 5.0 in southern West Virginia is: black walnut—2 feet; white pine—6.6 feet; red maple—8 feet; and sycamore—6.3 feet.

Direct seeding of black walnut has not produced better stands than transplanting. In Illinois, the survival rate by direct seeding was 41 percent. In West Virginia, SCS seedings using stratified seed or fall planting failed.

Larix decidua, European larch
Larix x eurolepis, 'Dunkfeld' hybrid larch
Larix leptolepis, Japanese larch

European and Japanese larch were among the first species to be used by SCS in the reclamation of acid coal mine spoil in Pennsylvania during the 1940's. Bramble (3) reports that Japanese larch is the best conifer in survival and height growth in Pennsylvania plantings. Japanese larch was superior to European larch in test plantings on acid spoil in LRA's 124, 125, 126, and 127. Brown (4) reports that European larch performed poorly in West Virginia.

'Dunkfeld' hybrid larch was planted in LRA's 125, 126, and 127. It was inconsistent in growth within the hybrid. Regardless of site, performance was erratic. After a few years of observations, its evaluation was discontinued.

In LRA's 124, 126N, 127N, and 147, Japanese larch grew well and provided moderately good cover in 4 to 5 years on acid spoil above pH 4.5. As the canopy closed, the annual needle fall provided fair to good mulch. This is in sharp contrast to other conifers, whose initial growth is usually slow and needle fall is insignificant until 8 to 10 years have elapsed. Red and white pine are two conifers that can surpass Japanese larch in 20 to 25 years, except on acid spoil below pH 4.5. Japanese larch has a slightly better survival rate than the pines and usually provides better stability to spoils.

In LRA 127S, the growth of Japanese larch is erratic and stands of uniform growth are rare. Form, vigor, and survival are usually poor in LRA 127S, except on northern exposures at elevations above 3,000 feet. In LRA 126S, all larch plantings performed poorly.

It is difficult to secure dormant planting stock of larch south of its normal range of adaptation. All species of larch initiate spring growth early, and this frequently begins in the nursery before they are dug. Planting stock is often damaged by heat during shipping and storage. It is for these reasons that the survival rate of many larch plantings has been below 50 percent. Recorded performance of Japanese larch follows:

147-A-17——4 in x 30 ft (red pine—3 in x 25 ft)
127N-VA-13——2 in x 20 ft (80-percent survival rate)
127-A-13——4 in x 25 ft (red pine—2 in x 13 ft)
127N-SA-25——4 in x 24 ft (white pine—5 in x 30 ft)

Liquidambar styraciflua, sweetgum

Typical of its normal range, sweetgum performed best in LRA 125 and the southern parts of LRA's 120 and 124. It is not adapted to spoil acidity below pH 5.0, but it grows extremely well at pH 6.0 and above. Best growth was observed where soil moisture conditions do not limit plant growth. In LRA 126S, fair stands resulted when these conditions were met. In southern Illinois, Limstrom and Deitschman (14) report growth of 4 inches by 28 feet in 8 to 10 years on limy spoil. Performance recorded in other areas follows:

120-SA-13——3 in x 18 ft (comparable to red and white pine)
125-A-10——4 in x 22 ft (comparable to river birch and sycamore)
127-A-15——2 in x 15 ft (superior to red oak and sycamore)

Liriodendron tulipifera, yellow poplar

Yellow poplar has been used in LRA's 120 and 124 as a component in commercial plantings. It grows best on slightly acid spoil and on the lower part of slopes and in cove-like areas. In Illinois it is very compatible with black locust.

On acid and droughty sites, yellow poplar grows slowly and is soon overtopped by sycamore, silver maple, and sweetgum. In LRA's 126 and 127, survival rates and vigor were fair. However, yellow poplar was not tested sufficiently in these two areas to draw firm conclusions. Brown (4) reports a survival rate of 80 percent in West Virginia, but growth was poor because site conditions were not suitable for yellow poplar. Performance ratings follow:

120-SA-13——3 in x 25 ft (equal to sweetgum, sycamore, and white pine)
124-SA-13——3 in x 25 ft (sycamore was 4 in x 35 ft)

Picea abies, Norway spruce
Picea pungens, blue spruce

Spruce requires more nutrients and water than pines. For this reason performance on spoil has been poor except where site conditions were favorable. In West Virginia a survival rate of 65 percent was reported for 10-year-old plantings but the average height was only 4 feet. This is typical of many spruce plantings in the Appalachian region but spruce usually establishes and initiates a later growth cycle if moisture conditions are favorable. On acid spoil in LRA 127, Norway spruce 20 to 25 years old was approaching red and white pine in height.

On nearly neutral spoil in LRA 124, Norway spruce was chlorotic but after 8 to 10 years it grew more rapidly. Because of its shade tolerance, Norway spruce remains in the understory of other tree species at reduced height growth. Comparative height of Norway spruce follows:

126N-A-25——spruce 22 ft, scotch pine 30 ft
127-A-13——spruce 10 ft, red pine 13 ft, Japanese larch 20 ft
147-A-13——spruce 12 ft, white pine 22 ft

Pinus spp., the pines

In general, pines are slower to establish and provide cover than black locust and European black alder. Pines were planted extensively in all LRA's. The performance between species varied but overall survival rates have been as good as those of hardwoods, except for black locust and European black alder. Usually pines take 5 to 10 years to establish a good root system. Once this is accomplished, it is common for white and red pine to grow 25 to 30 inches annually.

Pines are not suitable for stabilizing mine spoil unless supplemented with herbaceous cover that can persist for 8 to 10 years. Pines grow slowly on steep, erodible sites. Erosion exposes roots, thereby slowing growth or killing the plant.

Pines have special uses for vegetating mine spoil to which most hardwood species are not suited. White pine is shade tolerant and persists in the understory of fast-growing tree species. Virginia pine is one of the more acid-tolerant species, and within its range of adaptation it may perform better than European black alder. The survival rate of Virginia pine is perhaps second only to black locust when established by direct seeding. Red and Scotch pine are excellent for use on droughty sites at elevations below 2,000 feet. Their evergreen foliage is of value for beautification, wildlife cover, and screening scars left by strip mining.

Many pines are susceptible to defoliation and terminal growth damage by insects. Pines should be planted in mixtures with other tree species to lessen insect damage.

Pinus banksiana, jack pine

Jack pine was included in many SCS plantings during the 1940's. Its use was discontinued in the Appalachian region because of its poor form and failure to perform better

than pitch or Virginia pine. Defoliation by the pine sawfly (*Neodiprion* spp.) was responsible for most of its poor performance in Pennsylvania (12). Survival rates were 40 percent in Pennsylvania and about 56 percent in Indiana and Illinois. Boyce and Neebe (2) report that in Illinois, jack pine grows best when planted in pure stands on spoil with a pH of 6.5 and above. Height recorded in 1975 follows: 120-SA-13—10 to 20 feet and 126N-A-20—15 to 20 feet (comparable to pitch pine).

Pinus echinata, shortleaf pine

Shortleaf pine is not well adapted to eastern coal mine spoil. Survival rate is about 20 to 30 percent on acid spoil to 60 percent on slightly acid spoil. Performance is best in LRA 125 and the southern part of LRA's 120 and 126. Exposed sites common to most mine spoil subject shortleaf pine to winter injury and severe mechanical damage caused by heavy wet snow.

In southern Illinois, shortleaf pine grows best on spoils between pH 4.5 and 6.9. Infestations of tip moth (*Rhyacionia frustiana*) can be severe. In this area its resistance to winter damage is better than that of loblolly pine (2). Comparative height on site 120-SA-13 was: shortleaf pine—15 feet; jack pine—12 feet; and pitch pine—8 feet.

Pinus nigra, Austrian pine

Growth of Austrian pine on acid and slightly acid mine spoil is nearly equal to that of red pine. It is reported to be more acid tolerant and not as susceptible to damage from European pine shoot moth (*Rhyacionia buoliana*) as red pine. Survival rate where Austrian pine was evaluated was less than 50 percent, and growth rate was about 1 to 2 feet annually after the fifth year.

Pinus pinaster, Spanish pine

Spanish pine was included in only one planting located in LRA 126S on slightly acid spoil. Initial survival was more than 70 percent, but stands steadily declined and most plants were dead after 15 years. Survival and growth of other tree species on the same site were normal.

Pinus pungens, table-mountain pine

The only planting observed was in western Pennsylvania (126N-A-25). Size of planting was one-fourth acre, survival was good, but form was poor compared to other conifers. Review of the literature indicates little testing of this species.

Pinus resinosa, red pine

This is one of the better pine species for revegetating mine spoil if used in areas where the European pine shoot moth is not prevalent. Brown (4) rates red pine as the second best conifer for planting in LRA 127S (West Virginia).

Red pine is best adapted to acid spoil above pH 4.5. It grows more rapidly after planting than most other pines and for this reason should be considered for sites that are unstable (see figure 4).

In Indiana and Illinois, red pine is recommended for use only on the northernmost coal fields and on droughty sites. In Pennsyl-

Figure 4.—A 3-year-old planting of red pine and black locust on acid spoil in LRA 127S.

vania, survival of red pine is as good or better than most of the pines (16). Performance recorded in 1975 follows:

120-SA-13——3 in x 18 ft (growth compares to white pine)
126N-A-25——9 in x 45 ft (open stand, single tree, average growth)
127N-A-25——6 in x 40 ft (typical stand growth)

Pinus strobus, white pine

White pine is well adapted to a wide climatic range and to spoil acidity above pH 4.5. It is planted extensively in all LRA's. Where not damaged by the white pine weevil (*Pissodes strobi*), its growth is surpassed by few tree species. Survival rates are good, except on very acid spoil. Because it is shade tolerant, white pine is ideal for mixed plantings. White pine develops slowly on exposed ridgetops and severely eroded sites. Growth is stunted where acidity is high or toxic elements are present. On such sites, Austrian, Virginia, and Scotch pine may grow better.

White pine does not provide adequate soil protection for the first 8 to 10 years of growth. Where mixed with black locust, surface litter about 1 inch deep accumulates in about 10 to 12 years. Many white pine plantings showed an annual growth rate of 24 to 36 inches after 8 to 10 years. Performance recorded in 1975 follows: 124-SA-18—8 inches by 35 feet (mixed stand); 127N-A-13—4 inches by 20 feet (pure stand); and 127S-A-19—11 inches by 40 feet (open stand).

Figure 5.—This 5-year-old stand of Scotch pine on acid spoil in LRA 125 has an average height of 40 inches and a survival rate of less than 50 percent.

Pinus sylvestris, Scotch pine

Scotch pine has been planted extensively throughout the eastern coal mining region and is considered to be one of the better conifers for use on spoil. Brown (4) rates it as the best conifer for spoil in West Virginia based on survival rate, growth, and adaptability. Hart and Byrnes (12) report a survival rate of 80 percent for plantings in Pennsylvania but after 10 years the canopy had not closed and provided little protection to the spoil surface. Limstrom (13) recommends Scotch pine for use on spoil of pH 4.5 to 6.0 throughout Ohio, Indiana, and Illinois. It is also well adapted to the anthracite coal fields in eastern Pennsylvania (see figure 5). Scotch pine should be planted where red and white pine are unsuitable because of likely insect damage. Performance recorded in 1975 was: 125-A-10—3 inches by 18 feet and 127N-A-13—5 inches by 25 feet.

Pinus taeda, loblolly pine

Loblolly pine is adapted only to LRA 125 and the southern part of LRA's 114 and 120, where excellent growth has been reported (2). Loblolly is subject to severe damage from cold and snow in the northern part of its range. In LRA 125, it tolerates a spoil pH of 4.5 and above. At this acidity level the survival rate was equal to that of white pine. In southern Illinois, the survival rate was about 54 percent.

Loblolly pine is the best tree species for seeding on mine spoil in Tennessee (27). Better stands developed when loblolly pine was seeded in mixtures with Virginia pine. SCS included loblolly pine in test plantings in southern West Virginia. The planting stock came from nurseries in Kentucky. Establishment was good but severe winters soon

increased mortality to nearly 100 percent. Comparative performance for 125-A-10 recorded in 1975 was: loblolly pine—6 inches by 30 feet, and Scotch pine—3 inches by 18 feet.

The growth rate of loblolly pine was greatly improved where it was planted in alternate rows with autumn-olive, a nitrogen-fixing shrub. During a 10-year period in southeastern Kentucky (LRA 125), diameter growth increased 1 to 2 inches more than where loblolly was planted in pure stands.

Pinus thunbergii, Japanese black pine

Performance of Japanese black pine in SCS plantings in LRA's 126 and 127 does not warrant its use on mine spoil. Survival and growth rates were fair to poor and cover was poor. This species is not adapted to very acid spoil.

Pinus virginiana, Virginia pine

Virginia pine is adapted to all spoil groups but only to the southern part of Illinois, Indiana, and Ohio, elevations below 2,000 feet in West Virginia, and all of Kentucky and Tennessee. Growth is moderate and survival rate is usually more than 50 percent. Although Virginia pine tolerates a pH of 3.5, performance is much reduced and growth is slow. Normally the form of Virginia pine is poor.

Virginia pine is the conifer best suited to direct seeding in its area of adaptation. However, stands have not been uniform and seldom provide adequate cover unless combined with compatible grasses and legumes at the time of seeding. With the exception of loblolly pine, other conifers are much inferior to Virginia pine when direct seeded. Overseeding on open stands of herbaceous cover has been partially successful. Phosphorus fertilizer improved stand quality in LRA's 125 and 126.

Plantanus occidentalis, American sycamore

Extensively tested throughout the coal fields, American sycamore shows a definite site adaptation to spoil above pH 5.5 in LRA's 114, 120, 124, and 125. On limy spoils in Indiana and Illinois, it is planted in mixtures with other hardwoods. See comparative performance under *Acer saccharinum*. Sycamore is not well adapted to spoil in LRA's 126 and 127.

Populus deltoides, eastern cottonwood

Eastern cottonwood has been planted extensively in LRA's 114 and 120 in mixtures with other hardwoods. It grows more rapidly than most species, especially on slightly acid to nearly neutral spoil. It is adapted regionwide and has good to excellent growth on less acid spoils. Survival rates are usually 70 percent or more except on very acid spoil. Little or no canker was found. Erosion control value is poor on steep slopes even after the canopy is closed. Planting stock of eastern cottonwood is not readily available. Comparative performance in 127S-A-16 was: cottonwood—12 inches by 55 feet, red oak—4 inches by 25 feet, and black alder—4 inches by 30 feet.

In LRA 126S, height ranged from 2 feet to 20 feet on the same site after four growing seasons, probably because of varying degrees of spoil acidity, compaction of spoil, or quality of planting stock. Eastern cottonwood volunteers readily onto most spoil. Quaking aspen (*P. tremuloides*) and bigtooth aspen (*P. grandidentata*) also volunteer.

Populus spp., cottonwoods

Numerous cottonwood plantings were observed in Pennsylvania, Ohio, Kentucky, and Indiana. Most SCS plantings failed. Stem canker infected all stands. Usually the diameter at breast height was 6 to 8 inches before stands declined. Pulpwood production can be considered on an 8- to 10-year rotation where spoil acidity is above pH 5.0 and available moisture is adequate.

Prunus serotina, black cherry

SCS plantings were limited to acid spoil in LRA 127S. Only one of three plantings was successful. It was at an elevation above 3,000 feet in an area where many native

stands of black cherry grow. Survival rate was about 90 percent. The other two plantings were on similar spoil at elevations of about 1,200 feet. Survival rate and vigor were poor on both sites.

In Pennsylvania, plantings on acid spoil (between pH 4.1 and 4.8) had a survival rate of 80 percent after seven growing seasons. Annual growth rate was about 12 inches.

Quercus acutissima, sawtooth oak

Adequate growth was limited to sites in LRA's 125, 126S, and 127S where moisture conditions were favorable and the pH was above 5.0. Growth was very slow the first 4 to 6 years. During this time sawtooth oak was preferred as browse by deer and damage was frequently severe compared to other tree and shrub species. Survival rates were slightly more than 50 percent. Two 16-year-old stands in LRA's 125 and 127S had trees 20 to 25 feet high. Acorn production had not started.

Quercus rubra, northern red oak

Plantings were extensive throughout the region. Performance varied considerably. Damage from rodents and deer was common and may explain the variable growth. In many test plantings, northern red oak was suppressed by faster growing tree species. This happened to some extent in mixed hardwood plantings in Ohio, Indiana, and Illinois.

Northern red oak is best adapted to spoil pH above 5.0. Height of trees in one 16-year-old planting in LRA 127S on acid spoil decreased from 30 feet to 10 feet as the spoil acidity increased from above pH 5.0 to 4.0. Comparative performance follows:

Site	*Species*	*Performance*
120-SA-13	red oak	4 in x 30 ft
	sycamore	6 in x 35 ft
127S-A-16	red oak	4 in x 30 ft
(Fayette Co., W.Va.)	sycamore	1.5 in x 18 ft
	European black alder	4 in x 35 ft
126N-A-25	red oak	4.5 in x 30 ft
(Indiana Co., Pa.)	Scotch pine	6 in x 35 ft
	Norway spruce	3 in x 22 ft
	gray birch (multistemmed)	3 in x 25 ft

Robinia pseudoacacia, black locust

Throughout the eastern coal mining region, black locust is the best tree species for providing quick cover and stabilizing a wide variety of sites above pH 4.5. Survival rates are normally well above 80 percent. At a spacing of 6 feet by 7 feet the canopy closes in 4 to 5 years. Voids are filled because black locust can reproduce by root suckers and produces seed at an early age. Also important is its ability to fix nitrogen at rates of as much as 50 pounds per acre annually. This, combined with the leaf litter and light shade black locust provides, creates an environment that encourages the invasion of herbaceous cover (see figure 6).

In LRA 127S, growth of black locust is reduced at elevations above 2,500 feet. Above 3,000 feet, European black alder grows better

Figure 6.—This 7-year-old stand of black locust on acid spoil in LRA 125 is 15 feet high and has a survival rate of 90 percent.

and provides more cover. Correspondingly, performance of black locust declines as plantings are extended northward into Pennsylvania. There, its best growth is on slightly acid spoils.

Because of its ability to produce uniform, dense stands, it has been used in pure plantings more than any other tree species. Severe infestations of locust borer (*Megacyllene robiniae*) usually occur in pure stands, most of which have been damaged beyond commercial use. Because black locust regenerates from seed and root suckers, the quantity of vegetative cover seldom decreased. Most SCS plantings included a small percentage of black locust for comparison. When black locust was less than 5 percent of the total stand, little damage by the locust borer was noted. Likewise, stands in Indiana and Illinois that have a small percentage of black locust in the hardwood mixture are free of the locust borer.

Black locust is the easiest hardwood species to establish by direct seeding. However, this method of reforestation seldom produces full stands. Brown (5) reports that 50 percent of seedings in West Virginia failed and only 20 percent produced adequate stands.

At one time, broadcast seeding of black locust and sericea lespedeza was the only method used to vegetate steep slopes in the Appalachian Mountains. These plantings were not uniform and stand density was not predictable enough to meet standards required by state law.

Newly developed methods for aerial and hydroseeding of black locust and temporary grass species have produced better stands. Such seedings include fertilizer, seed for temporary grass cover, and scarified black locust seed.

Borer-resistant, dominant-stemmed clones of black locust have been selected by SCS. About 20 of the more adaptable clones were planted in sufficient numbers to confirm the selection of BN-4191 for form and rapid growth rate. Unfortunately it is somewhat susceptible to the locust borer and therefore has not been released for commercial production.

Shrubs, vines, and brambles

The performance ratings of shrubs, vines, and brambles in table 2 and the following text are based on rapidity of growth, percent of cover, and time necessary to fulfill the normal function as a shrub, vine, or bramble. For example, a shrub that normally produces a thicket-type growth from root suckers but failed to do so on mine spoil was rated poor because it did not perform in a manner typical of the species. Its cover value would also be rated poor. The performance of most shrubs was compared to that of 'Cardinal' autumn-olive.

Plants suited to special uses were evaluated for their ability to thrive and perform according to the specific characteristics of growth they normally have on well-drained, undisturbed soils. For example, crabapples were not evaluated for erosion control but for their ability to grow at a normal rate, persist on the site, and produce a moderate amount of fruit for wildlife.

The following text discusses the performance of the most widely tested shrubs, vines, and brambles.

Amorpha fruticosa, indigobush
Amorpha glabra, mountain indigo

These legumes normally grow to a height of 12 to 15 feet, but on spoil, 8 to 10 feet is more common. They have open crowns with moderately dense foliage and a form similar to that of sumacs. They grow and produce vegetative cover more slowly than autumn-olive. Both species are adapted to the eastern coal mining region and can grow at pH 4.0, as well as on slightly alkaline spoils.

Indigobush was the better of the two species for use on mine spoil. Survival rates using 1-0 planting stock were commonly 90 to 95 percent. Sutton [1] reports survival rates of 95 percent in a planting of 300 seedlings on acid spoil in Ohio.

[1] Paul Sutton, Ohio Agr. Res. and Dev. Cent., Wooster, Ohio, personal correspondence, September 24, 1975.

Indigobush tolerates acid spoil, fixes nitrogen, and produces a dense herbaceous ground cover (see figure 7). Although slow to develop cover, it is ideal as a site conditioner for invasion of native species. One site (126S-A-15) is now 50 percent aspen, black locust, and cherry, with a ground cover of grasses and forbs. In Ohio, Riley (21) observed little or no regeneration in spite of heavy annual seed production.

Aralia spinosa, hercules-club or devil's walking stick

A few plantings were made during 1960 and 1961 on all three spoil groups in LRA's 126 and 127. Mortality was high. Some of the plants are still alive but are performing poorly. Hercules-club tolerates very acid spoil with a pH of 3.5 but does not produce adequate cover.

Berberis koreana, Korean barberry
Berberis thunbergii, barberry

Growth and form of plants observed on several test sites in 1975 were normal. Survival rate was 25 to 30 percent on acid spoil in LRA 126N. U.S. Forest Service plantings on acid spoil in Kentucky had a survival rate of 48 percent.

Figure 7.—This 2-year-old indigobush has a well-nodulated root system after one growing season on acid (pH 5.0) spoil. The seedling was planted as 1–0 stock.

Neither species was sufficiently tested to confirm its use and adaptation. Only four plantings were reported in LRA's 125 and 126N. Three were observed in 1975. On one site in Pennsylvania (126N-A-25), the plants were 3 to 4 feet high and 2 to 3 feet wide and had a heavy set of fruit in October. Cover was poor because the plants were too far apart. In Kentucky, plants were moderately vigorous and growth was normal for the species.

Colutea arborescens, bladder-senna

This is a leguminous shrub, 8 to 10 feet tall and heavily branched from the base, that reproduces readily from root suckers and seed. All plantings in West Virginia, Virginia, and Kentucky were severely damaged by early frosts and severe winter temperatures. Partial stands have persisted for more than 20 years on acid spoil but the cover produced is poor. There is little indication that this species fixes as much nitrogen as autumn-olive and indigobush. In LRA 126S, deer prefer this species as browse to autumn-olive, silky dogwood, and purpleosier willow. Bladder-senna is not suited to conservation use within the areas tested. Spreading by seed into waste areas and fields can occur.

Cornus amomum, silky dogwood
Cornus racemosa, graystem dogwood
Cornus stolonifera, red-osier dogwood

Silky dogwood has been tested over a longer period and more extensively than the other two species of dogwood. None is outstanding for erosion control.

Silky dogwood is a native shrub that produces fruit in summer. Once established, it persists unless crowded out by invading trees. However, silky dogwood is not suitable for erosion control. Compared to autumn-olive, its rate of growth, adaptability to acid sites, and cover value are poor. Survival rates of silky dogwood are reported to be 55 percent in Pennsylvania and 35 percent in Kentucky. Comparative performance of silky dogwood as observed in 1975 follows:

Site	Species	Stand	Height
125-A-4	silky dogwood	34 pct	2.8 ft
	autumn-olive	48 pct	5.4 ft
	indigobush	90 pct	2.4 ft
127N-A-13	silky dogwood	30 pct	3 to 4 ft
	autumn-olive	80 pct	10 to 12 ft
	indigobush	60 pct	6 to 7 ft
127S-A-10	silky dogwood	open	4 to 7 ft
	autumn-olive	dense	15 to 20 ft
	purpleosier willow	dense	15 ft
	sawtooth oak	open	3 to 15 ft

Cytisus ratisbonensis
Cytisus scoparius, Scotch broom
Cytisus supinus, big flower broom

These woody legumes grow upright, have moderately fine stems, and reach a height of 3 to 8 feet. They are usually evergreen, except in the northern part of their range. Survival rate has generally been less than 50 percent and is lowest in LRA's 126 and 127. All three species survived winter temperatures but were partially damaged each winter unless growing in a protected site. Riley (21) reported that 4-year-old stands in Ohio had good vigor and that plantings were successful on spoil between pH 4.5 and 7.5.

Elaeagnus angustifolia, Russian-olive

Russian-olive is adapted only to spoil that has a pH above 5.5. One 20-year-old stand in LRA 126N had good survival and an average height of 25 feet. It was severely damaged by wet snow although no damage was evident on adjacent hardwood or coniferous trees or shrubs. Many plantings on acid spoils in LRA's 126 and 127 failed. Performance in LRA 114 is reported to be good. Its cover value is poor in southwestern Virginia. It is also a very poor seed producer in eastern Kentucky. Russian-olive has been tested by Riley (21) and others but no outstanding qualities have been reported.

Elaeagnus commutata, silverberry

Only one planting of silverberry was observed. It was located in LRA 126N on slightly acid spoil and was about 25 years old in 1975. The plants were 8 to 10 feet tall, which is less than half the normal height. Russet buffaloberry on an adjacent plot was 18 feet high. Silverberry exhibited its strong stoloniferous growth habit but plants were dying after the fourth and fifth year. This planting has been under observation for more than 15 years and during this period it failed to produce fruit. Cover value was poor.

Elaeagnus multiflora, cherry elaeagnus
Elaeagnus pungens, thorny elaeagnus

Cherry elaeagnus and thorny elaeagnus were included in an evaluation planting by the U.S. Forest Service in Kentucky. They had better survival rates than autumn-olive but neither grew as vigorously (20). Observations of cherry elaeagnus in 1975 indicate that it is as good as or better than autumn-olive on acid spoil in LRA 125. The number of plants tested was not sufficient to warrant a conclusion but does indicate that this species should be further evaluated.

Elaeagnus umbellata, autumn-olive

'Cardinal' autumn-olive is well adapted to a wide variety of mine spoil conditions from a pH of 4.0 to slightly above 7.5 (see figure 8).

Figure 8.—A 7-year-old stand of 'Cardinal' autumn-olive on a severely eroded, acid spoilbank in LRA 125. On this site most woody species, except European black alder and black locust, failed to provide any protection.

It is outstanding for its early and vigorous growth, high survival rate, and exceptional cover-producing qualities that are surpassed only by black locust. Because of its nitrogen-fixing ability, it has a beneficial effect on adjacent plants. Autumn-olive has a beneficial effect on tall fescue. In Tennessee (LRA 128), it tolerates a spoil pH of 3.2. Autumn-olive can be planted as 1-0 stock. Spacings of 8 feet by 8 feet have given adequate protection on spoils of pH 5.5 in LRA 125. Autumn-olive can grow to a height of 20 feet or more with a crown spread equal to its height. The canopy is dense, shade is heavy, and few plants grow in its understory. The lower branches of autumn-olive are commonly semiprocumbent and interlock with adjacent autumn-olive plants. Where planted at spacings of 6 feet by 6 feet it is impossible to walk through stands after 8 to 10 years.

Production of fruit takes place about the third or fourth year, and few shrubs surpass it for yield. Fruit ripening is spread out over several weeks in spoilbank plantings, and some plants retain fruit until late in December. Leaf fall is late, which makes autumn-olive useful for screening.

Fall and spring seedings with stratified and treated seed have not been successful. However, autumn-olive has spread by seed to adjacent areas in LRA's 126S and 147. Its fruit is eaten by songbirds and spreading in this manner can be expected. See the genus *Cornus* for comparative performance of autumn-olive.

Lespedeza bicolor, bicolor lespedeza
Lespedeza bicolor, 'Natob' bicolor lespedeza
Lespedeza japonica, Japan lespedeza

These three species of lespedeza are well adapted to mine spoil if planted within their range of climatic adaptation. All tolerate a pH of 4.5 but grow better at pH 5.0 and above.

Seedlings are usually planted as 1-0 stock spaced 3 to 4 feet apart in rows 6 feet apart. The plants also can be established by seeding provided the spoil is scarified and fertilized. Direct seeding of bicolor and 'Natob' bicolor on unprepared outer slopes produces good stands if done early in spring and soon after grading operations are completed.

These species provide fair to poor cover for erosion control. Japan lespedeza provides the most cover of the three and produces denser stands when seeded.

Survival rate and stand persistence are good. In 124-A-17 bicolor lespedeza had 90-percent survival, in 125-A-10 Japan lespedeza had 88-percent survival, and in 127N-A-5 'Natob' bicolor lespedeza had 77-percent survival. The northern limits for consistent seed production are LRA's 114, 120, and elevations below 1,500 feet in 126S for Japan lespedeza; LRA's 124, 126N, and elevations below 2,500 feet in 127S for bicolor lespedeza; and LRA 127N for 'Natob' bicolor lespedeza.

Ligustrum amurense, amur privet

Although not tested extensively, amur privet has shown good survival, vigor, and persistence on acid and slightly acid spoil. In LRA 126N, stands are in excellent condition after 20 years and were surpassed only by autumn-olive for survival of shrub species.

Amur privet does not appear to be adapted to spoil pH below 4.5 but grows well at pH 5.0 and above. In LRA 125, 10-year-old stands had variable growth depending on the spoil reaction, which ranged from pH 4.0 to 5.0.

This species is not normally used for erosion control but is useful for screens and hedges. All plantings observed were either clump plantings or single rows. It is fairly shade tolerant and persists in strong competition with other shrubs. Very little spreading by seed was noted.

Lonicera maackii, 'Rem Red' amur honeysuckle
Lonicera tatarica, tatarian honeysuckle

There is little difference in adaptation and performance between these two species, except in date of fruit maturity. They are inferior to autumn-olive in survival rate, growth rate, yield of fruit, and ability to produce cover and stabilize spoil. Maddox [2] reports similar findings in Tennessee.

[2] Joe B. Maddox, Div. For., Fish., and Wildl., TVA, Norris, Tenn., personal correspondence, August 6, 1975.

The growth rate of honeysuckles is much reduced as acidity increases, and plantings should be restricted to areas where spoil pH is above 5.0. They are winter hardy in all LRA's. Honeysuckles grow slowly the first 2 years. This is a handicap, especially on slightly acid to neutral spoil, where white sweetclover (*Melilotus alba*) volunteers and competes strongly with the young seedlings.

Honeysuckles were usually planted as 1-0 stock spaced 6 feet by 6 feet. Normally they are not suitable for stabilizing steep slopes or critical areas unless planted with herbaceous species.

Because both species initiate spring growth earlier than most shrubs, heat damage to seedlings while in transit is a hazard. This may explain the low survival rates of about 60 to 70 percent. A 14-year-old stand in LRA 127S had grown 6 to 10 feet, the crown spread had closed the stand, and some litter was accumulating.

Both species reproduce by seed, and spread to adjacent areas is common. Tatarian seeds mature in July and August and are eaten or drop from the plant shortly thereafter. 'Rem Red' amur honeysuckle seeds mature in September or October and may remain on the plant well into winter.

Direct seeding on bare mine spoil was not successful. Regeneration of plants does not occur on mine spoil until some organic matter accumulates and partial shade is available.

Maclura pomifera, osage-orange

Use of osage-orange has been limited to LRA's 114, 120, and 126N. Performance varied. In LRA 126N, two plantings 20 and 25 years old on slightly acid spoil had a survival rate of less than 40 percent and growth was about half that of plants on undisturbed soil. Plantings in Illinois had a 31-percent survival rate.

Malus spp., crabapples

The largest number of test plantings was in LRA's 126 and 127. In general, survival and growth rates were good and stands persisted in spite of heavy competition. The expected mortality from browsing deer and rodents did not occur. In other LRA's, growth was retarded by deer browsing but no plants were killed.

Davis (7) reports that in Pennsylvania after the first growing season, Asian crabapple had the highest survival rate of five shrub species, which included autumn-olive, Tatarian honeysuckle, silky dogwood, and multiflora rose. Riley (22) reports that in Ohio two species of crabapple had 100-percent survival after 4 years. Performance of crabapple recorded in 1975 follows: 127S-A-15—10 feet wide by 12 feet high, produced fruit in 5 years; 126N-SA-25—70-percent stand, 20 feet high, excellent fruit crop; 126S-A-13—12 feet wide by 12 feet high, fair fruit crop; 126N-VA-13—spoil pH below 4.0, 20-percent survival, 8 feet wide by 12 feet high, some fruit. These plantings were not fertilized and did not receive any kind of management.

The recommended use of crabapples is for wildlife food or beautification. A spacing of 20 feet by 20 feet plus a ground cover of grasses is recommended. Do not plant on sloping spoil. Spoil pH should be at least 5.0. Where deer or rodents are plentiful, fertilizer is not recommended to supplement growth of crabapples because this increases their palatability over other woody species that are not fertilized.

Pueraria lobata, kudzu

SCS field evaluation of kudzu has been limited because many landowners are reluctant to plant this spreading vine. Kudzu's rapid growth and spread beyond its area of use are well known.

Kudzu was planted to test its ability to screen high walls 75 to 100 feet high. Two sites were selected: one in northern West Virginia (LRA 126S) and the other in southwestern Virginia (LRA 127S). In these plantings, common kudzu was compared to a hardy strain from Kehtan, China. The strain from Kehtan was more hardy and vigorous and survived winter temperatures at both sites (see figure 9).

Kudzu was established vegetatively on both sites. It spread rapidly and was effective as a

screen for unsightly mine spoil. Later, five more plantings were established vegetatively but they were overgrazed by livestock and eventually failed.

Plantings on steep, rough areas in LRA 126S by private landowners developed slowly, but once crowns were well established, kudzu spread rapidly and produced excellent cover. Grandt and Lang (10) report that kudzu has been planted in Illinois on ungraded, limy spoil for both cover and livestock feed.

Kudzu requires a spoil pH of 5.5 or more and a balanced fertilizer equivalent of 500 pounds of 10-10-10 per acre at time of planting. All successful plantings observed so far have been on slightly acid spoils. A seeding rate of 1 to 2 pounds per acre is usually sufficient. A prepared seedbed is best, and straw mulch helps in establishing kudzu in its northern range of adaptation.

Robinia fertilis, 'Arnot' bristly locust

'Arnot' bristly locust is a thicket-forming shrub adapted to all LRA's in the eastern coal mining areas (see figure 10). It is outstanding for its rapid juvenile growth and quick cover on all types of spoil. It tolerates a spoil pH of 3.0 in Ohio and has good vigor at a spoil pH of 3.2 in Tennessee.

'Arnot' is an open-branched woody legume that grows to a height of 8 to 10 feet in 4 to 5 years. Stand density increases rapidly by root suckers that begin to form during the first growing season. Root suckering frequently increases as erosion exposes the roots and stimulates new growth. This particular growth habit of forming dense thickets in spite of erosion makes 'Arnot' one of the best erosion-control plants, especially for acid spoils. Besides fixing nitrogen, 'Arnot' has many fine stems resulting from root suckering that serve as barriers against which leaf litter accumulates rapidly. One-year-old seedlings are suit-

Rhus aromatica, fragrant sumac
Rhus copallina, shining sumac
Rhus glabra, smooth sumac
Rhus typhina, staghorn sumac

These are native shrubs that grow in all LRA's. Of the four species, shining sumac has the best growth characteristics for use on mine spoil. It tolerates a pH of 4.0, and on less acid sites it spreads by seed and root suckers. Fragrant sumac is slightly less acid tolerant and less aggressive. Smooth and staghorn sumac were not tested sufficiently to determine their tolerance to acid spoil. Their normal growth habit is more upright and open and not as desirable for cover as the lower growing shining sumac.

Survival rates for the sumacs have been more than 70 percent on spoils above pH 4.5, and growth correspondingly improves as acidity decreases. On site 127S-A-15, shining sumac had full stands and heights of 6 to 7 feet and fragrant sumac had open stands and heights of 3 to 4 feet. About 25 percent of both species showed evidence of browsing. Suggested use for sumac is large wildlife plantings of 100 to 200 plants spaced 4 to 5 feet apart. None of the sumacs is well suited to erosion control.

Figure 9.—A 9-year-old planting of kudzu from Kehtan, China, established vegetatively on slightly acid spoil in southwestern Virginia (LRA 127S). The spoil was ungraded and difficult to hand plant to trees. Cover formed rapidly after the third year, and complete stabilization was provided by the ninth year.

able for mine spoil plantings. A spacing of 6 feet by 6 feet is usually sufficient.

'Arnot' was collected in 1958 as *Robinia hispida* by the SCS Big Flats Plant Materials Center, Big Flats, New York. Later it was reidentified as *Robinia fertilis* and subsequently named and released in 1969 as 'Arnot'. There has been some concern that this species may spread and become a pest similar to multiflora rose. Repeated observations have been made, and no spreading of this kind has been detected. Spreading by seed is unlikely since it is not readily eaten by songbirds, and no evidence of spreading by seed has been observed. Spreading by root suckering is reduced greatly or does not occur in areas with sod cover. Some spreading into partially covered waste areas adjacent to plantings of bristly locust has been noted. In one area (126N-SA-10), 'Arnot' spread only 25 feet from the original planting in 10 years.

Many plantings 12 to 15 years old are losing their aggressiveness as other woody species invade and dominate the stand. Mine spoil plantings in LRA's 125 and 126S have decreased in size after 15 years. A slow invasion of sericea lespedeza is taking over the plantings in LRA 126S. The plantings in LRA 125 (Kentucky) are being defoliated by a leaf roller (*Larger canna*), but cover is not reduced because other species have invaded the site. In Indiana, 'Arnot' is reported to be a more desirable nitrogen-fixing plant than black locust, mainly because of its shrubby growth.

Rosa multiflora, multiflora rose

Multiflora rose is not adapted to very acid spoils. Better establishment and growth occur on spoils of pH 5.0 and above. When multiflora rose plants reach a height of 5 to 7 feet, the dense foliage provides good cover. Usually the crown is as wide as or wider than the plant height, and the canes are procumbent, adding to the degree of cover.

Reproduction of multiflora rose from seed is uncommon on bare spoil, but as vegetative cover increases and surface litter accumulates, regeneration begins. Spreading by seed is not limited to spoil areas. Seed is transported by birds, and spreading of this species has become widespread in some areas.

Rosa wichuraiana, memorial rose

This species is easy to establish with 1-0 planting stock. Short runners appear the second year and provide some erosion control. Prostrate growth continues. If planted at 5-foot centers, memorial rose provides moderate to good cover in 3 to 4 years. Runners 15 to 20 feet long are common. Many canes layer in the spoil when sediment covers the long prostrate stems. Total vegetative cover is seldom more than 70 percent, but erosion control is excellent after 8 to 10 years because litter accumulates.

Figure 10.—A 3-year-old planting of 'Arnot' bristly locust on acid spoil in LRA 126S. Typical of its spreading by root suckers, at least 10 new plants have formed from the parent plant. Note that the parent plant has seedpods.

Memorial rose is best adapted to slightly acid spoil. Stands persist in moderate shade. Memorial rose climbs trees and shrubs to a height of 10 feet. It spreads by seed in a manner similar to that of multiflora rose.

Variation in this species has been noted. Some plants are almost thornless. The color and size of fruit also vary. The seed source for most of the planting stock for SCS plantings came from a streambank planting in Pendleton County, W. Va.

Rubus allegheniensis, wild blackberry
Rubus hispidus, dewberry

Seed and plants collected from native stands of blackberry and dewberry failed to establish at spoil pH below 5.0 in LRA's 126 and 127.

Rubus parviflorus, trailing raspberry
Rubus pungens, trailing raspberry

Both species of trailing raspberry were planted. Survival rate was about 60 percent. Vigor and growth were poor. Very little ground cover was produced. However, plants persisted for 8 to 10 years.

Salix purpurea, purpleosier willow

This species was extensively tested on all spoil groups in SCS plantings from 1955 to 1960. It tolerates a narrow range of site conditions. Dieback is common on limy spoil in LRA's 114, 120, 124, and 125. It grows best on spoil of pH 5.0 to 6.0 in LRA 127N and at elevations above 2,000 feet in LRA 127S. In northern West Virginia, stands spaced 6 feet by 6 feet were closed after 20 years, plants were 15 to 20 feet high, and growth was vigorous.

Although early growth is prostrate on coal mine spoil, normal upright growth resumes after 3 or 4 years. Purpleosier willow is not useful for erosion control on mine spoil because the crown is narrow, leaf litter is sparse, and reproduction is poor.

Performance of other Salix species was not promising. Although the number of plantings was limited, investigations on spoil do not appear to be warranted.

Shepherdia argentea, russet buffaloberry

Three plantings indicate that russet buffaloberry has excellent vigor and stand quality. Its performance on spoil is similar to that of autumn-olive, but its ability to fix nitrogen is undetermined. After 25 years a planting in LRA 126N on slightly acid spoil is so dense it cannot be penetrated. Except for slow movement outward by seedlings, spreading has not been noted. Mature height is 18 feet. Buffaloberry is well adapted to slightly acid spoil in Indiana, where growth is similar to that of autumn-olive.

Viburnum dentatum, arrowwood
Viburnum plicatum var. tomentosum, doublefile viburnum
Viburnum trilobum, American cranberrybush

Plantings of arrowwood on slightly acid and acid spoil in LRA 126N have been under observation for 20 to 25 years. Survival rate could not be determined, but height growth and form were normal. Arrowwood is shade tolerant and was thriving in an understory of invading hardwood trees. In LRA 125, arrowwood had poor survival rate and fair vigor on acid spoils after 10 years.

American cranberrybush was observed in LRA 126N on two sites that had no competition from invading woody plants. After more than 20-years growth, plants were 6 to 8 feet tall and fruit production was normal for the species. Survival rate was poor on acid spoil and good on slightly acid spoil.

Herbaceous species

Procedures for field testing

Under most circumstances a dense ground cover is needed to control soil erosion on surface-mined land. A fast-growing tree, such as black locust, requires 4 to 8 years to form a closed canopy and much longer to adequately stabilize spoil. Herbaceous plants are therefore essential to provide quick and effective cover. Furthermore, grasses and legumes adapted to spoil conditions are needed for forage, wildlife, and other uses.

For these reasons, extensive collection and screening to find herbaceous plants adapted for use on mine spoil was started in the early fifties. At that time, sericea lespedeza was the only legume suitable for use in the Appalachian region on areas too steep to hand plant to trees. Sweetclover was easy to establish on slightly acid spoil throughout the coal fields, but it was short lived and provided little erosion control. Few grasses provided long-term protection, and the common grasses could not be established without lime, fertilizer, and seedbed preparation on other than unusually fertile spoils.

Plant materials having desirable characteristics were assembled and planted to determine their suitability for providing stabilizing cover. Plant materials were selected for seedling vigor, low fertility needs, drought tolerance, ease of establishment, winter hardiness, aggressiveness, persistence, and low maintenance requirements. Species native or already naturalized to the area were tested.

First to be screened were the commercially available species. Plantings after 1959 included new species or improved strains made available through SCS plant materials centers. Techniques for establishing plants also were tested. Plantings were made in cooperation with both state and federal agencies, soil conservation districts, colleges and universities, and coal mining companies.

Seedbed preparation

Because seedbed preparation is not practical on most spoilbanks, it was necessary to determine which species could be established without a prepared seedbed. Evaluation plantings were made under one or a combination of the following conditions:

1. Frost seeding on steep slopes. Frost seeding is done late in winter or early in spring and depends on frost action to work the seed into the soil.
2. Seeding on fertilized and unfertilized spoil. Studies by Grandt and Lang (10) and Hart and Byrnes (12) indicate that spoilbanks derived from acid shale and sandstone are very low in nitrogen and phosphorus and moderately low in potash. They also reported that slightly acid spoils are moderately high in phosphorus and potash but extremely low in nitrogen. Soil sample tests in the Appalachian region confirmed these reports. Consequently, a complete fertilizer of a 1-1-1 ratio was used in most fertility studies.
3. Seedings on graded spoil, with and without scarification.

Time of seeding

Most plantings were done in spring. Spring seedings other than frost seedings were done within the period recommended for each land resource area. According to Struthers (25) there is little advantage in fall seedings.

Plot location and size

In the Appalachian region, plots were located both on the leveled bench and the steep outer slopes. In this region, contour strip mining is most common and the long outer slopes are the main source of sediment.

Size of plots varied according to the topography of the spoil, availability of plant materials, and facilities for planting or seeding. Most plots were 150 to 400 square feet.

Use of fertilizer

In 1959, studies of the effect of fertilizer on establishing plants were initiated in LRA 126S on acid spoil and slightly acid spoil. Fertilizer and seed were broadcast early in

spring on unprepared seedbeds. Twenty-three grasses and legumes were tested. Four plots of each grass or legume were fertilized at the following rate per acre: one with 50 pounds of nitrogen; one with 250 pounds of 10-10-10; one with 500 pounds of 10-10-10; and one was not fertilized.

Based on the results of these plantings, additional fertility studies were made in LRA's 125, 126S, 126N, 127S, 127N, 128, 140, and 147.

Concurrent studies were conducted on acid spoils to determine the effect of lime, fertilizer, and seedbed preparation on a few of the more promising grasses and legumes. Acidity was adjusted to pH 6.5, and spoil was fertilized with 500 pounds of 10-10-10 per acre. The studies were conducted on three sites. All seedings were made in rod rows. Rows of each species were treated as follows: one row treated with lime and fertilizer, one row treated with fertilizer alone, and one row left untreated.

Species that were adapted to certain spoil groups and that could be established with a minimum of fertilizer were further tested in 20 additional plantings. These plots were usually 20 to 50 feet wide and extended downslope 50 to 100 feet. Plot size depended on the topography and availability of seed. Seed was applied at a rate 25 percent higher than the recommended seeding rate for agricultural land.

While these studies were conducted by SCS in the Appalachian region, studies were conducted in LRA's 114, 120, and 125 by state agricultural experiment stations, the U.S. Forest Service, and Kent State University, Kent, Ohio.

These studies indicate that most cool-season grasses cannot be established without fertilizer on any type of spoil. Fertilizer was essential to the establishment of most commercial forage species, regardless of spoil group. On slightly acid spoils, nitrogen alone was sufficient to establish grasses, and during the first 2 years application of a complete fertilizer did not improve the rate of cover over nitrogen alone.

Some species of warm-season grasses and legumes were established without fertilizer on acid spoil above a pH of 5.0, and a large number were established without fertilizer on slightly acid spoil.

Seedbed preparation was beneficial for all new seedings, especially on leveled, compacted spoils. Good stands of some species were established by frost seeding on ungraded spoil not compacted by earthmoving equipment.

Spoils with a pH of 4.0 to 4.5 were difficult to vegetate regardless of the amount of fertilizer applied. Studies by the U.S. Forest Service and the Agricultural Research Service indicate that applications of rock phosphate help to establish cover on acid spoils. No attempt was made to correct the acidity of very acid spoil. Some very acid spoil was fertilized and seeded but with no success.

On slightly acid spoils, 300 pounds of 10-10-10 fertilizer per acre was sufficient for the establishment of warm-season grasses and the more persistent legumes. Acid spoils required at least 500 pounds of 10-10-10 fertilizer. Where species were seeded for forage, 500 to 1,000 pounds of fertilizer was needed and liming to a pH of 6.5 was as effective as on undisturbed cropland.

Regardless of the type of spoil and the LRA, very few stands of cool-season grasses were established without the use of fertilizer. Nitrogen and phosphorus affect growth of grasses most. Phosphorus is less limiting on some spoils, particularly those that are slightly acid.

Many native warm-season grasses persist at lower fertility levels than introduced cool-season grasses. Warm-season grasses were evaluated to find herbaceous cover that would grow at low fertility levels. These grasses are not usually early invaders on critical areas, such as coal mine spoil, so it was anticipated that some adjustment to the spoil would be necessary. The first seedings were in the Appalachian region, on steep, acid spoils. It was not until after 1965 that seedings were made on prepared seedbeds that were limed and fertilized.

On slightly acid spoils, applications of 50 pounds of nitrogen per acre produced stands of grass equal to applications of 500 pounds per acre of a 10-10-10 fertilizer. Little difference was noted in stand density or percent of cover for the first 2 years. On spoils with a pH between 4.5 and 5.5, a complete fertilizer was always more effective than nitrogen

alone. At best, stands of cool-season grasses on acid spoil were of short duration in comparison to the same species grown on slightly acid spoil.

Grasses

Over a period of 20 years a wide range of grasses was tested, including summer and winter annuals, short- and long-lived perennials, and cool- and warm-season grasses.

The use of grasses for long-term cover is not promising. Grasses generally show little adaptation to low-fertility sites. On fertilized spoil they can be established but most fail to persist when grown alone. They persist only in association with legumes. Those that do persist, such as the native grasses, are slow to develop and sometimes difficult to plant and establish.

A prepared seedbed always produced better stands of grass than an unprepared seedbed. Many grasses could not be established without some covering of the seed. Frost seedings were less effective with grasses than with legumes. Spoil graded with earthmoving equipment is usually very compact, and scarification or loosening of the spoil to a depth of 4 or 5 inches was necessary for a good seedbed. Lime and fertilizer should be applied before the seedbed is prepared. The more vigorous grasses, such as tall fescue and ryegrass, can be established by frost seeding.

Performance ratings of all species according to spoil groups and land resource areas are provided in table 4. The ratings in the table are the average performance of the species based on the percent of cover and ability to provide long-term cover. Therefore, those grasses having value only as short-term cover are rated poor or failed in the table. The following text reviews performance characteristics other than persistence of cover.

Agropyron desertorum, crested wheatgrass
Agropyron intermedium, intermediate wheatgrass
Agropyron repens, quackgrass

Fair to good stands of wheatgrasses were established on slightly acid spoils in Pennsylvania and West Virginia. The wheatgrasses grew poorly on acid spoils and did not respond to complete fertilizer. Grandt and Lang (10) report good stands of western and crested wheatgrass on acid spoils in Illinois. Stands in the East did not persist and gave way to encroaching volunteer species.

In comparison to tall fescue or orchardgrass, the wheatgrasses were not as leafy nor did they provide adequate cover. In Kentucky, tall wheatgrass did not provide dense cover and did not respond to applications of fertilizer. The best stand of intermediate wheatgrass was observed during its third growing season on slightly acid spoil in LRA 127N. Cover was about 40 percent.

All seedings of quackgrass were on unfertilized spoil. Establishment was poor and stands failed to develop. This may have been the result of poor seed quality, since the seed used was a waste product from a seed-cleaning process.

Agrostis alba, redtop

Redtop was established quickly and provided good cover for 3 to 4 years at a pH of 5.0 and above. It requires fertilizer for establishment on infertile spoil and responds well to a prepared seedbed. In the Appalachian region it is possible to establish redtop on steep outer slopes if it is seeded shortly after the overburden is placed. In LRA 126S, seedings made 2 years after grading on slightly acid spoil failed.

The best stands of redtop were in LRA 127. Redtop is better suited to the climate in this area than farther south or at lower elevations. Stands of 80-percent cover were common by the second growing season, provided fertility requirements were met. Cover value declined rapidly after the fourth year, and by the eighth year the stand had usually died out.

Grandt and Lang (10) report that redtop is well adapted throughout Illinois and grows well on infertile spoil.

Andropogon caucasicus, caucasian bluestem

Caucasian bluestem was very aggressive and vigorous in forage plantings in LRA 127,

but broadcast seedings on coal mine spoil have been unsuccessful. Broadcast seedings were made at low fertility levels and on unprepared seedbeds. Caucasian probably would do as well under improved cultural practices as the other bluestems.

Andropogon gerardi, big bluestem
Andropogon scoparius, little bluestem

Stands of both species were very slow to become established on unfertilized spoil and provided very little protection. Many stands failed at pH levels below 4.8. Most stands were so poor that they were invaded rapidly by other species.

On properly limed and fertilized sites big bluestem produced good stands in 8 years whereas little bluestem on similar sites performed poorly. Stands were not uniform with either species and would have benefited from a companion species.

In Pennsylvania, seeding bluestem at or near the last killing frost at a rate of 12 pounds per acre produced good stands. Bluestem was difficult to establish on sites being invaded with forbs. Applying less nitrogen than normally recommended for the spoil group helps reduce competition.

Figure 11.—Tall oatgrass in its second growing season on acid (pH 4.5 to 5.0) spoil. The spoil was fertilized with 500 pounds of 10–10–10 per acre. There was no other seedbed preparation. Seed was broadcast early in spring for a frost seeding.

Andropogon virginicus, broomsedge

Seed of local ecotypes of broomsedge was collected from nearby spoilbanks and seeded directly on spoil at the time of autumn seed dissemination. Broomsedge hay was harvested and applied as mulch in an attempt to establish stands in that manner. Both methods failed. The percentage of pure live seed was low in all collections but not low enough to explain all failures.

Aristida spp., three-awn

Three-awn is a native grass that invades many spoil areas in LRA 127S. It was collected and seeded as was broomsedge but all seedings failed.

Arrhenatherum elatius, tall oatgrass

Tall oatgrass provides excellent short-term cover at moderately low fertility levels and is especially adapted to droughty soils in the Appalachian region. Good stands developed in all SCS plantings, and tall oatgrass is rated as the best grass for short-term cover (see figure 11). Density of cover is comparable to that of redtop and stands persist 4 to 6 years. It is adapted to spoils in Ohio, Indiana, and Illinois.

Bromus spp., bromegrass

Many species of bromegrass (see index) were seeded on very acid (pH 3.5 to 4.0) and acid (pH 4.8 to 5.0) spoils on steep outer slopes in LRA 126S without the use of fertilizer. The best bromegrass in this planting was rescue grass, which produced 10-percent cover on acid spoil. All others failed to develop any cover on either spoil group.

Smooth brome is considered to be one of the best cool-season grasses for forage on coal mine spoil in Illinois. Stands persist if seeded in mixtures with alfalfa. In LRA's 126 and 127, smooth brome was slow to become

established on limed and fertilized spoils and cover was poor in comparison to tall fescue.

Cynodon dactylon, bermudagrass

Evaluation of bermudagrass was restricted to acid spoil in LRA 125. All plantings failed after several years. Bennett (1) reports that bermudagrass tolerates acid spoil if rock phosphate is added to the spoil. Work by the U.S. Forest Service indicates that fertilizer is needed for establishment but that stands seldom last more than 3 to 4 years.

Dactylis glomerata, orchardgrass

On spoils prepared for grass seedings, orchardgrass is inferior to tall fescue for cover, stand establishment, and persistence. In LRA 126S in West Virginia, mixed stands of orchardgrass and birdsfoot trefoil on slightly acid spoils were productive for more than 15 years. Seedings on outer slopes in LRA's 125, 126, and 127 failed regardless of soil reaction unless the spoil was fertilized. Reports from Illinois indicate that it is well adapted to spoils derived from limestone.

Digitaria spp., crabgrass

Nine species (see index) were investigated as summer annuals for possible use on spoils difficult to vegetate. Seedings were made on unfertilized steep slopes without seedbed preparation. All seedings failed on spoils between pH 3.5 and 5.0 in LRA 126S. In comparison, stands of switchgrass and deertongue produced up to 20-percent cover by the third year on spoil of pH 5.0.

Elymus giganteus, mammoth wildrye
Elymus triticoides, creeping wildrye
Elymus virginicus v. glabriflorus, Virginia wildrye

Virginia wildrye was seeded only on one site at a pH of 5.0 in LRA 127S. Seed failed to emerge. Both mammoth wildrye and creeping wildrye were planted vegetatively on unfertilized acid spoil. These plantings were not successful. Mammoth wildrye produced a good stand on one site in LRA 127S, but two stands failed in LRA 125.

Eragrostis curvula, weeping lovegrass
Eragrostis ferrunginea, Korean lovegrass
Eragrostis trichodes, sand lovegrass

Weeping and Korean lovegrass were included in plantings on acid spoil (pH 4.5) near Morgantown, W. Va., in 1958. Seedling vigor of lovegrass, where fertilized, was so outstanding in comparison to cool-season grasses that additional testing was begun.

Weeping lovegrass was found to be excellent for quick but temporary cover on outer slopes. Stands did not persist more than 2 or 3 years in LRA's 125 and 126S. In LRA 127, weeping lovegrass was usually killed during winter. The only effective cover was from the remaining mulch. Longevity of stands of weeping lovegrass is determined by site fertility and winter hardiness. As a rule, longevity is greater on southern exposures. In comparison to perennial ryegrass, weeping lovegrass has the advantage of thriving on more acid spoil, it can be seeded more successfully late in spring and early in summer, it is better suited to southern and western exposures, and it produces more mulch.

Comparative plantings of Korean lovegrass and weeping lovegrass show that Korean is not as acid tolerant and on slightly acid spoils it lacks the vigor of weeping lovegrass.

In Indiana and Illinois, sand lovegrass has been useful in mixtures with switchgrass. Sand lovegrass provides the necessary cover until the slower growing switchgrass gains vigor.

Festuca arundinacea, tall fescue

Tall fescue performed well on spoil and was the most versatile of the grasses evaluated. It grew throughout the region on a wide variety of site conditions and provided good cover when fertilized. Seeds germinate quickly and seedlings are vigorous. It was easy to establish by aerial seeding or hydroseeding.

In LRA's 125, 126, and 127, good stands seldom produced more than 60- to 70-percent cover. SCS plantings indicate that

tall fescue stands do not persist long unless mixed with an adapted legume. The best stands were on slightly acid spoil. As spoil acidity increased, the life of the stand decreased unless maintained by repeated applications of fertilizer. Duration of cover varies with the inherent fertility of the spoil. Tall fescue should not be considered useful as permanent cover unless planted in mixtures with a persistent legume such as sericea lespedeza, crownvetch, or flatpea.

SCS evaluation plantings indicate that tall fescue persists longer in LRA 127N than other cool-season grasses except timothy. Stands on acid spoil seldom produced more than 50-percent cover and began to decrease by the third or fourth year. Fair to good stands developed on outer slopes of slightly acid spoil but weakened and disappeared in 6 to 8 years.

In Illinois, tall fescue is one of the more vigorous grasses and is used for winter forage on spoil (9).

In LRA 125, stands were of short duration unless mixed with a legume and cover was poor by the sixth to eighth year.

In comparative plantings in LRA 127S on spoil of pH 5.2 after 15 years, tall fescue stands had completely died out whereas switchgrass and indiangrass had 60-percent cover and were increasing on steep sites; crownvetch and flatpea had 100-percent cover; birdsfoot trefoil had 30-percent cover; and sericea lespedeza had about 80-percent cover.

Seeding tall fescue does not restrict the growth of woody plants, provided the woody species have rapid juvenile growth similar to that of black locust or Japanese larch. A study by Plass (19) confirms this.

In southwestern Virginia, black locust seedlings planted concurrently with an overseeding of tall fescue produced nearly 100-percent cover at the end of five growing seasons.

Festuca rubra, red fescue

Red fescue is well adapted to the climate in LRA 127N, where it is as long lived as tall fescue and provides better cover and is more tolerant of low-fertility spoil than timothy and orchardgrass. Red fescue also grows well at elevations above 2,000 feet in LRA 127S, but stands in LRA's 125 and 126 are only fair and do not provide adequate cover. In Indiana, red fescue volunteers on black locust plantings and seedings are moderately successful.

Lolium perenne, perennial ryegrass

Perennial ryegrass can be used in all LRA's for quick, temporary cover. It can be established in either spring or fall and successfully planted from the air or by hydroseeders. Fertilizer is required for good cover (see figure 12).

Perennial ryegrass does not grow as well as weeping lovegrass on spoils below pH 4.5 in the Appalachian region. However, ryegrass is better adapted to LRA's 126N and 127N, where stands may last into the third year. In those areas, weeping lovegrass is winterkilled the first year. Ryegrass does not successfully reseed to perpetuate the stand. Percent cover produced by ryegrass varies

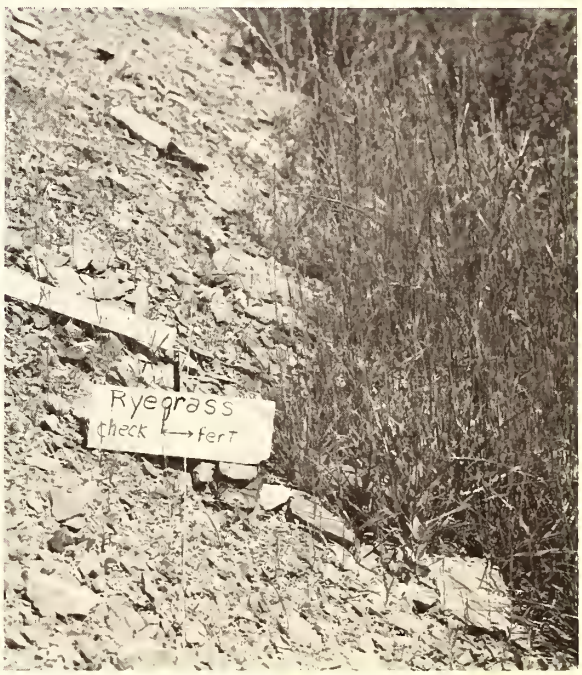


Figure 12.—A plot of perennial ryegrass 3 months after frost seeding on the outer slope of acid (pH 5.2) spoil in LRA 127S. The area to the left was unfertilized. The area to the right was fertilized with 500 pounds of 10–10–10 per acre. Where fertilized, ryegrass provided good cover for 2 years. The unfertilized plot did not provide adequate cover.

considerably with site, fertility, seedbed, and season of the year.

Ryegrass is very competitive when planted as a nurse crop with slow-growing legumes or woody species. It produces nearly 100-percent cover in 2 to 3 months and this rapid growth suppresses emerging legumes.

Miscanthus sinensis, Chinese silvergrass (plumegrass)

Chinese silvergrass is a tall, robust perennial grass used mainly as an ornamental that has become naturalized in some areas of the Northeast. It was planted both vegetatively and by seed. All seedings failed but vegetative pieces grew vigorously. Single pieces of root material produced clumps 18 inches in diameter in 15 years. Chinese silvergrass grows on slightly acid spoil and thrives at a pH of 4.5 to 5.0 in LRA 127S. Cover quality is poor at a spacing of 6 feet by 6 feet. Its narrow form is excellent for standup cover, screens, and hedges. Average height is 6 to 7 feet and leaf spread is nearly 4 feet.

Panicum amarulum, coastal panicgrass
Panicum amarum, bitter panicum

Neither of these species could be established by seeding on unfertilized acid and slightly acid spoil. Vegetative plantings were successful on spoil at pH 5.2. Both species grew well but there was little or no spread by rhizomes. Only coastal panicgrass produced seed and was reported to be growing well after 3 years on fertilized acid spoil in Ohio.

Panicum clandestinum, deertongue

A grass native to the Northeast, deertongue invades low-fertility acid sites. It is a warm-season perennial that grows to a height of 18 to 36 inches and spreads by rhizomes. Its outstanding conservation values are an extensive fibrous root system that more than equals the top growth and its ability to thrive at acidity levels of pH 4.0.

As is true of other warm-season grasses, fertilizer is needed to establish stands of deertongue. Below a pH of 5.0, nitrogen and phosphorus are also essential. However, once stands are established they persist without additional site treatment.

Two plantings of deertongue in LRA 126S and LRA 127S were established on light-textured spoils at a pH of 5.0. The seedbed was not prepared, and only 250 pounds per acre of 10-10-10 fertilizer was applied. After 10 years, both had 100-percent cover and were spreading outside the plot boundary. All cool-season grasses planted at the same time had died out.

In Ohio, Sutton (see foonote 1) reports difficulty in establishing deertongue at a spoil pH below 4.0, whereas bristly locust and Japanese fleeceflower were tolerant of the site.

In LRA 140, deertongue was comparable in stand and cover to other grasses after 5 years on spoils with a pH of 5.0. Deertongue grew more vigorously than switchgrass, big bluestem, and indiangrass. A December seeding of deertongue was successfully established the following spring.

Two accessions of deertongue were evaluated: NY-1325 (which originated in West Virginia) and NY-4950 (a blend of 20 accessions developed at the Big Flats Plant Materials Center). NY-4950 was released as 'Tioga' in 1975. Reports indicate that NY-4950 is more vigorous and easier to establish than NY-1325.

Several plantings of deertongue in Illinois are reported to be successful but they were not on very acid spoil. After 2 years deertongue was superior to hard fescue in a comparative planting in LRA 114.

Stand development and erosion control improve where deertongue is planted in combination with bristly locust. Both are acid tolerant and suited to similar site conditions. The nitrogen fixed by bristly locust and the light shade it provides improve site conditions for deertongue. Black locust has a similar effect on deertongue.

Evaluation plantings indicate that seeding late in fall or very early in spring is necessary to break seed embryo dormancy. Deertongue should have 30 days of field stratification. It responds to added phosphate and appears to grow best on light-textured spoils.

Panicum virgatum, switchgrass

Switchgrass has been planted in all LRA's and is a useful warm-season grass for providing cover throughout the eastern coal mining region. It grows best on slightly acid spoil on which it can be established by frost seeding without a starter fertilizer if the spoil is ungraded (see figure 13). Stands are difficult to establish on level, compacted spoil unless the site is scarified prior to seeding.

Switchgrass is slow to become established but usually grows well after the second year. It takes 2 years for stands to develop on acid spoil. Cover value is poor the first year and sites benefit from a light seeding of a short-term grass such as redtop, ryegrass, or weeping lovegrass. Once established, stands require very little maintenance.

In LRA 125, a 10-year-old stand of switchgrass had completely stabilized steep acid spoil. On similar sites 10-year-old plantings of conifer tree species did not provide the same quality of cover. Its robust growth produced ample vegetation to buffer raindrops and provided much more ground cover than most cool-season grasses.

Figure 13.—A 2-year-old stand of switchgrass seeded on slightly acid spoil in LRA 127S without seedbed preparation or fertilizer.

Switchgrass is suitable for use in tree plantings, whether planted at the same time or after the trees are planted. Several plantings in West Virginia (LRA 126S) included a combination of warm-season grasses with a planting of conifers. The pines grew without any competition from the grasses. Ground quality and quantity of cover increased rapidly in comparison to plantings without grass. After 10 years, the pine canopy had not closed and switchgrass provided more cover than the pines.

The Big Flats Plant Materials Center reports that switchgrass and birdsfoot trefoil are compatible for use in mixtures on spoils with a pH of 5.0. Switchgrass is used in Indiana in mixtures with sericea lespedeza and sand lovegrass. SCS plantings indicate that switchgrass is well adapted to most spoils in Indiana and Illinois (LRA 114). Grandt and Lang (10) note its value as summer forage on spoilbanks in Illinois.

In northern Ohio, switchgrass persisted on spoils of pH 4.5 for more than 10 years, whereas all cool-season grasses failed. These plantings were in furrows more than 12 inches deep.

Switchgrass may fail on unfertilized, acid spoils and where the seedbed is not sufficiently scarified. Several plantings in LRA 127S (West Virginia) at elevations above 3,000 feet failed, whereas tall oatgrass and red fescue, which are easier to establish, produced good stands.

'Blackwell' switchgrass was the cultivar most used in SCS plantings in LRA's 124, 125, 126, and 127. Other varieties and accessions were tested but differences in quality of stand and percent of cover were not sufficient to warrant their use. 'Pangburn' switchgrass was used in Tennessee and 'Cave-in-the-rock' was used in Illinois with some success but they were not appreciably better than 'Blackwell'.

In LRA's 126 and 127, a seeding rate of 8 to 12 pounds of pure live seed per acre is adequate on spoil of pH 5.0. Stands grow better when switchgrass is mixed with 10 pounds of birdsfoot trefoil. In LRA 125, mixtures with sericea lespedeza were successful, but in plantings with crownvetch and flatpea, switchgrass was soon overcome by those aggressive legumes.

Phalaris arundinacea, reed canarygrass

Reed canarygrass is very difficult to establish on well-drained spoils. However, once established it persists on spoils above pH 5.0 if fertilized. Where crownvetch has invaded cool-season grass plantings in Pennsylvania (127N-A-13) and Virginia (127-A-18), reed canarygrass was the only species to grow in competition with it. In LRA 126S reed canarygrass was much superior to tall fescue and nearly equaled switchgrass after 10 years of growth.

Phleum pratense, timothy

Timothy is adapted to all LRA's in the eastern coal mining region. Seedings failed on unfertilized spoil and on spoil of pH 4.8 and below, but good stands can result with seedbed preparation and proper fertilization.

In all LRA's except 127N, good stands did not persist more than 5 years and seedings on steep outer slopes, as a rule, did not provide adequate erosion control. Timothy is one of the common grass species to volunteer on coal mine spoil in LRA 127N, but volunteer stands are sparse and seldom last more than 2 or 3 years.

When seeded with legumes, timothy has produced good stands on slightly acid spoils in LRA 126N that have persisted for more than 10 years.

In LRA 127N, cooperative plantings with the U.S. Forest Service on acid spoil indicate that after 5 years, both tall fescue and red fescue produce better stands than timothy. In Illinois, timothy was not as persistent as smooth brome or tall fescue.

Sorghastrum nutans, indiangrass

Few of the 30 plantings of indiangrass made in the Appalachian region in the last 10 to 15 years have produced more than 30- to 40-percent cover (see figure 14). Many strains and varieties have been assembled at both the Big Flats and Quicksand Plant Materials Centers, but none has performed well on mine spoil. 'Cheyenne' was the variety most commonly used for comparative plantings with other grass species.

Although stands were sparse, indiangrass spread to adjacent mine spoil areas more than any other warm-season grass. Consideration should be given to including indiangrass in mixtures with other herbaceous species and to overseeding stands of slow-growing woody species with indiangrass.

Tridens flavus, purpletop

Purpletop is one of the more common native eastern grasses. It usually invades infertile fields after other herbaceous species have established cover. Seed from local collections of purpletop was seeded on all three spoil groups with no success. Fertility of the spoil had little or no effect on stand development. The best stands of purpletop appeared several years after seeding and only on sites that had been invaded by volunteer grasses and forbs. Typical of its growth habit in native stands, purpletop is not a primary invader and some cover is required to condition the

Figure 14.—A 5-year-old stand of indiangrass on acid (pH 5.2) spoil in LRA 127S. The open stand is typical of indiangrass. After 10 years, the cover had not increased but spreading by seed into adjacent plots was common. Indiangrass overseeded on 2-year-old plantings of conifers provided good supplemental cover without competing with the conifer seedlings.

site before it will invade. In LRA 127, purpletop invaded plantings on acid spoil and has persisted for 15 years.

Tripsacum dactyloides, eastern gamagrass

Eastern gamagrass was established only vegetatively. Survival rate was more than 80 percent on spoils above pH 5.0. Stands have persisted for 15 years and have increased slightly through natural seeding. Individual plants on spoil are less robust than those growing on undisturbed soils but they have slowly increased in size through rhizomatous growth. Cover value was poor at spacings of 6 feet by 6 feet. Growth was semiprocumbent, seed stalks were spindly, and seed production was about normal. Seed was produced during the second growing season. Stands in LRA 127S on spoil with a pH of 5.3 spread 25 feet in 15 years.

Legumes

Selected long-lived herbaceous legumes are perhaps the most important group of plants for vegetating strip mine spoil. However, the initial cover provided by legumes is usually inadequate for erosion control and temporary grasses must be seeded with legumes to provide quick cover.

Grasses usually benefit from being planted in mixtures with legumes. The nitrogen produced by the legumes lengthens the stand life of cool-season grasses and increases the vigor of warm-season grasses. Care needs to be exercised in selecting grass species and seeding rates to avoid suppressing the legumes. An excellent method is to seed a temporary grass cover, then overseed with a permanent legume as the grass begins to thin out.

Some legumes require specific site and climatic conditions for establishment and continued stand development. For example, crownvetch is sensitive to soil acidity during the seeding year and requires a pH of no less than 5.5 for good germination, emergence, and seedling development. In contrast, sericea lespedeza is less sensitive to a pH of 4.5 to 5.5 than most legumes but has severe climatic limitations. Its adaptation is restricted by the length of the growing season and by winter temperatures.

Grass-legume mixtures used for cover on mine spoil usually are dominated by one or the other species. Exceptions to this under certain site conditions are the following mixtures if seeded at rates 25 percent higher than recommended for agricultural land: sericea lespedeza and switchgrass in LRA's 127 and 124; crownvetch and reed canarygrass in LRA's 127N and 127S; birdsfoot trefoil and timothy in LRA 127N; birdsfoot trefoil and tall fescue in LRA 126S; alfalfa and smooth bromegrass in LRA's 114 and 120.

Table 4 gives performance data for legumes. The following text discusses the most important species tested.

Astragalus cicer, cicer milkvetch
Astragalus falcatus, sickle pod milkvetch
Astragalus glycyphyllos, milkvetch

Milkvetches have not been planted on spoils in sufficient quantity to warrant any conclusion. However, plantings in LRA's 114, 120, and 125 do not indicate any outstanding performance.

Cassia fasciculata, partridge pea

Partridge pea is a reseeding annual that has produced fair stands for up to 5 years in LRA 120. Elsewhere plantings have been poor or failed on acid spoil and fair on slightly acid spoil.

Coronilla varia, crownvetch

Where adapted, crownvetch is the best legume for providing early and continuous cover at minimum cost in establishment and maintenance (see figure 15). On ungraded spoils and outer slopes and on slightly acid spoil crownvetch can be established without seedbed preparation or fertilizer. However, fertilizer and seedbed preparation insure uniform stands and quicker cover. It is best to seed crownvetch late in winter or early in spring to allow frost action to cover the seed.

Crownvetch produces complete cover in 2 to 3 years.

Crownvetch has many features that make it desirable for use as a cover plant:

1. It is a strong, robust legume. As a seedling it may appear weak, but a tap root descends that enables it to withstand adverse conditions fatal to many other species.
2. Stand density increases rapidly because new plants form from spreading root stock by the second growing season.
3. Crownvetch adds considerable amounts of nitrogen to the spoil.
4. Its dense and semireclining topgrowth buffers the spoil from raindrops, and a heavy mulch forms quickly from annual yields of dry matter that amount to as much as 2 to 4 tons per acre.

In all LRA's are excellent stands 15 to 20 years old. No other legume provides as much desirable forage and erosion control. It is winter hardy, initiates spring growth early, and thrives equally well in the northern and southern parts of the eastern coal mining region.

Crownvetch requires a pH of 5.5 or more for establishment by seeding. Once a good stand develops, it tolerates a greater degree of acidity. In LRA 127S, stands 10 years old are on spoil of pH 4.5. In LRA's 126 and 127 are many areas where crownvetch has spread to unlimed spoils with a pH below 5.5.

Figure 15.—A 2-year-old stand of 'Chemung' crownvetch frost seeded on unfertilized spoil early in spring provides 100-percent cover. Black locust on the left is 3 years old.

On spoils with a pH above 6.5, applying a complete fertilizer does not increase significantly the percent of cover. In West Virginia, many such spoils were frost seeded and produced complete cover by the second or third year without fertilizer.

On spoils of pH 4.5 to 5.5, applying up to 1,000 pounds of 10-10-10 fertilizer per acre improved the percent of cover provided the acidity was adjusted to pH 6.0 to 6.5.

Fifteen pounds of seed per acre is adequate for broadcast seeding on outer slopes of most slightly acid spoils. The seeding rate on southern and western exposures should be increased to 20 pounds per acre. Where seedbeds are prepared and fertilized, the seeding rate can be reduced to 10 to 12 pounds. Crownvetch develops more slowly where the spoil has been compacted by earthmoving equipment.

First-year cover can be improved by adding 15 to 20 pounds of perennial ryegrass to the crownvetch seeding. Observations in LRA 126 indicate that tall fescue and orchardgrass have not been as effective as ryegrass when mixed with crownvetch.

Complex seed mixtures and heavy seeding rates of grasses delay the development of crownvetch stands but seldom prevent it. Sweetclover also retards crownvetch growth, but in 6 to 7 years crownvetch dominates the sites.

In LRA's 126 and 127S, crownvetch seeded at a rate of 5 pounds per acre following planting of black locust and European black alder on outer slopes produced excellent cover. Crownvetch is somewhat shade tolerant and has persisted for more than 10 years in these plantings. Crownvetch is too vigorous to be planted with conifers during the year of tree establishment. Crownvetch can be successfully established on graded or leveled mine spoil provided the spoil is scarified and fertilized. In LRA's 124 and 126, crownvetch is used for forage in mixtures with other legumes and grasses and cattle gains of as much as 1.98 pounds per day are reported (17). The cultivar 'Chemung' was

used for all SCS plantings in the Appalachian area. Performance of crownvetch compared with three other legumes on the outer slopes of mine spoil in LRA 126S follows:

Spoil pH	Age in years	Percent ground cover			
		Crown-vetch	Flat-pea	Sericea lespedeza	Birdsfoot trefoil
6.0	5	100	65	10	40
6.0	12	100	100	70	—
5.0	10	100	75	75	0
4.8	10	0	25	50	—

Lathyrus sylvestris, 'Lathco' flatpea

'Lathco' flatpea is one of the newest conservation plants for use in the East. It is more acid tolerant than crownvetch and more winter hardy than sericea lespedeza and maintains a pure stand better than most legumes (see figure 16).

Unlike crownvetch or sericea lespedeza, it is a climbing perennial. Because of this growth habit and its exceptional vigor and dense, leafy foliage, flatpea usually suppresses invading forbs or woody plants.

Figure 16.—On this 65-percent slope, 'Lathco' flatpea provided 100-percent cover in 3 years whereas sericea lespedeza on an adjacent plot provided less than 50-percent cover.

These growth characteristics are an advantage where maintenance is a problem or where low ground cover is desired for wildlife, utility rights-of-way, or open areas. This type of growth limits the use of flatpea in mixtures with other species.

Evaluation plantings indicate that flatpea requires the same soil reaction, seedbed preparation, and amount of fertilizer for establishment on mine spoil as crownvetch. One exception is that flatpea can be established at a spoil acidity of pH 5.0 without the use of fertilizer, but stands develop slowly. Sutton (see footnote 1) reports good stands and fair growth at a pH of 4.4 in Ohio. In LRA 125, where adequate fertilizer was applied, good stands were established at pH 4.1 to 4.5.

Flatpea can increase in stand density because of its rhizomatous growth habit. However, it does not spread as rapidly as crownvetch and produces complete cover 2 or 3 years later than crownvetch.

Because of the large, heavy, round seed, broadcast plantings of flatpea are not as uniform as those of legumes with smaller seed, except where the seedbed is prepared. Large seed is an advantage on long steep slopes that are difficult to seed, even with hydroseeders. Flatpea seed carries much farther than sericea seed or light, chaffy grass seed. In evaluation plantings, seed was broadcast by hand more than 100 feet on downhill slopes.

In LRA 127S, a 15-year-old planting of flatpea is growing vigorously on a spoil of pH 5.0. During this period, all invasion of woody species has been suppressed and spreading to adjacent areas has been minimal.

Flatpea yields up to 5 tons of dry matter per acre annually and is reported to be a promising forage legume (23).

Lespedeza cuneata, sericea lespedeza

Sericea lespedeza is a warm-season legume. It is adapted only to LRA's 114, 120, 125, 126S, and 128, the southern part of LRA 124 in Ohio, and below 2,000-feet elevation in LRA 127S. It is a good cover plant for erosion control and grows on acid spoil within its area of adaptation. It has been used

longer than most legumes for stabilizing critical areas and its performance is well known to most conservationists. For this reason, it was used as the standard herbaceous legume for comparison in SCS evaluation plantings.

Sericea lespedeza does not always produce full stands and only on more acid spoil does it perform better than crownvetch or flatpea. Seedings can produce complete stands, but many are partial and erosion control is not adequate. In such stands the cover can increase only through reseeding (see figure 17) whereas crownvetch and flatpea can increase vegetatively as well as by reseeding. Fertilizer produces more uniform stands and increases the growth rate.

Its stiff, upright stems, bunch-type growth habit, and open stands make sericea lespedeza a desirable legume for seeding in mixtures with trees such as black locust and Virginia pine. Mixed seeding is a common practice for vegetating long, steep outer slopes in the southern part of the Appalachian Mountains. However, it is recommended only as a last resort. According to Brown (5), less than 20 percent of such seedings produce adequate stands of trees. Hand planting of tree seedlings followed by an overseeding of sericea lespedeza provides better cover.

Fifteen accessions of sericea lespedeza were evaluated on three sites in LRA 126S using common sericea lespedeza as the standard. Of these, a prostrate accession, KY-520, was the most vigorous. It consistently established good stands. KY-520 is under seed increase at the Quicksand Plant Materials Center in Kentucky. In LRA's 125 and 126S, KY-520 has produced good stands on mine spoil and has spread outside the plot boundary.

The following table shows the performance of sericea lespedeza in 65 evaluation plantings in southern West Virginia. All seedings were on unfertilized outer slopes.

Percent cover	Very acid spoil	Acid spoil	Slightly acid spoil
60 to 100	———	1	10
40 to 60	———	2	6
Less than 40	21	14	11

At the northern limits of its area of adaptation, sericea lespedeza produces better stands if the following techniques are used:
1. Seed at the rate of 35 pounds per acre when seeded alone. Reduce this rate by 40 percent if seeded with a grass.
2. Use a combination of one-half hulled and one-half unhulled seed.
3. Seed 1 month before the average date of the last killing frost for the area.
4. Apply a 1-2-1 fertilizer with at least 50 pounds of nitrogen per acre.

SCS evaluation plantings indicate that sericea lespedeza seedings must reach a height of 6 to 8 inches to be hardy enough to withstand winters at the northern limits of its area of adaptation. Early fall frost frequently kills young seedlings and prevents mature plants from setting seed.

In LRA 125, the cultivar 'Interstate' provided more cover than common sericea lespedeza after 4 years growth. The best stand of 'Interstate' had 80-percent cover where sites were fertilized before seeding. In Polk County, Tenn. (LRA 128), 'Interstate' produced good stands after two growing seasons.

Figure 17.—A stand of sericea lespedeza and tall fescue after 2 years on acid (pH 5.0) spoil in LRA 126S. Cover was 50 percent, which is typical for such a mixture. Voids in stands are common.

Lespedeza daurica, daurica lespedeza
Lespedeza daurica var. schimadai, prostrate lespedeza

These plants were field tested only in LRA's 114, 120, and 124. Daurica lespedeza usually established good stands the seedling year on slightly acid spoil but failed rapidly against competition from grasses and invading legumes and forbs. In LRA 124, it provided more cover the seedling year than sericea but failed to develop as competition increased. Prostrate lespedeza shows some promise for use on slightly acid spoils in Illinois. Many stands of prostrate lespedeza failed because of invading sweetclover. Prostrate lespedeza seeded in mixtures with switchgrass provides a suitable grass-legume mixture for acid spoils in Illinois.

Lespedeza stipulacea, Korean lespedeza

This is the best reseeding annual legume evaluated. It is adapted only to the southern part of the coal mining region. Its range is similar to that of sericea lespedeza. When seeded alone it produces at its peak growth period no more than about 60-percent cover. In LRA 126S, stands 4 to 5 years old provided 50-percent cover as the understory of a poor stand of conifers on acid spoil. In LRA 125, fair stands on acid spoil have maintained themselves for 10 years through reseeding.

Growth of Korean lespedeza ceases with the first killing frost and only the residue provides winter cover. It can grow in infertile soils and grows best at acidity levels above pH 5.0.

Fertilizer improves the initial stand but has little effect after the third year. Reports from Tennessee indicate good stand establishment in the second growing season. The cultivar 'Kobe' is reported to be more acid tolerant than Korean lespedeza.

On sites that are droughty or have a southern exposure, reseeding annual lespedezas should be considered for secondary or temporary cover pending the establishment of slow-growing legumes.

Lotus corniculatus, birdsfoot trefoil
Lotus tenuis, narrowleaf trefoil

The trefoils are cool-season legumes adapted to Illinois, Indiana, Ohio, Pennsylvania, and the mountain region of West Virginia. They can be established on spoil south of their normal area of adaptation if there is limited competition from other plants. In the southern fringes of their range of adaptation they are less susceptible to crown rot and other fungi on mine spoil than on undisturbed soil.

Narrowleaf trefoil has a more prostrate growth habit than birdsfoot trefoil. On outer slopes it can be established readily from seed and provides better cover than birdsfoot trefoil. Neither species, however, is comparable for erosion control to crownvetch or flatpea. Both crownvetch and flatpea are more widely adapted than the trefoils.

In LRA 126S, birdsfoot trefoil grows best when mixed with tall fescue. Stands of birdsfoot trefoil and tall fescue have been in existence for more than 18 years in LRA 126S, and trefoil still makes up 25 percent of the stand. Orchardgrass also grows exceptionally well in this area and may be too competitive to be mixed with trefoil.

In LRA 126S, trefoils grow best on fertile spoils that are slightly acid. On the infertile spoils typical of LRA 127, they grow best mixed with timothy but require frequent top dressing to maintain stands. In the southern part of LRA 125, trefoils lack vigor.

Fertilizer is required to establish stands of birdsfoot trefoil, except on spoils that contain high amounts of lime and moderate amounts of phosphorus and potash. 'Viking' is the most successful cultivar of birdsfoot trefoil tested. Others were 'Empire' and 'Mansfield'.

In LRA's 126 and 127, good stands of trefoil with a compatible grass are easily established provided the seedbed is prepared and lime and fertilizer are applied.

Compared to crownvetch and flatpea the trefoils are much inferior in cover qualities and are not suitable for seeding alone. Their best use is as a forage legume in mixtures with grass species.

The poor rating in table 4 reflects their performance on outer slopes when seeded in pure stands. It does not reflect their early seedling vigor and compatibility with cool-season grasses.

Medicago sativa, alfalfa

Alfalfa thrives on the slightly acid and more fertile spoils in Indiana and Illinois (9) and

grows well if mixed with smooth bromegrass. In the Appalachian region, cultural requirements make alfalfa generally unsuitable for mine spoil. Its value as a cover plant is poor.

Melilotus alba, white sweetclover

White sweetclover is a biennial legume adapted to all land resource areas but only to spoils with a pH of 6.0 and above. It volunteers readily where spoil pH approaches neutral, often to the detriment of seeded grasses and legumes. Its growth habit is quite typical of a biennial. It reestablishes itself by reseeding for a period of 3 to 5 years, but reseeded stands seldom are as vigorous as the first plants on the site. Other species usually invade the stand, and the percentage of sweetclover gradually diminishes. Many stands are attacked by sweetclover weevil or a root rot disease and disappear rapidly. In Indiana and Illinois, seeding sweetclover mixed with grasses provides fair forage (10).

Melilotus alba var. annua, Hubam sweetclover

This annual sweetclover was seeded on slightly acid spoil in LRA's 114 and 126N. In LRA 114, stands reseeded for a period of 5 years. In LRA 126N, annual sweetclover failed to reseed the first season whereas adjacent stands of common sweetclover continued their normal growth cycle.

Forbs

Most forbs reviewed here are native or naturalized species. Nearly all volunteer on coal mine spoil and are part of the normal plant succession on unplanted coal mine spoil. They are not commercially important and are classified as weed species in many states.

Seed and plants of most species were collected from volunteer plants on spoil or on infertile areas adjacent to coal mine spoil. Some materials were purchased.

Performance ratings for forbs are given in table 5. The following text discusses some of the most widely tested species.

Ambrosia artemisiifolia, ragweed

Ragweed was seeded in fall and spring in LRA's 126 and 127. Emergence was poor and stands failed to establish.

Carex spp., sedges

In LRA 127S, sedge plants collected from a volunteer stand on coal mine spoil were planted in spring on acid spoil. After 18 years the plants are still present and are spreading by seed into surrounding areas. The stand is open and cover is poor, which is typical of sedges growing on well-drained soils.

Chenopodium album, lambsquarters

Fall and spring seedings in LRA's 126 and 127 failed to establish a stand.

Desmanthus illinoensis, Illinois bundleflower

Stands failed in LRA's 114, 120, and 124.

Lactuca spp., prickly lettuce

Fall seedings failed in LRA's 126 and 127.

Liriope graminifolia, lilyturf

In both LRA 126 and LRA 127, lilyturf was planted vegetatively. Less than 50 percent of the stand survived the first year and all stands failed by the end of the second year. Sites were not fertilized.

Phytolacca americana, pokeberry

Scarified seed of pokeberry was planted in spring and fall on acid and slightly acid spoil in LRA 126S, but stands failed to emerge after 2 years. Plantings of the same seed produced full stands at the Big Flats Plant Materials Center in New York.

Plantago lanceolata, buckhorn plantain

In LRA's 126 and 127, stands seeded in spring failed to establish.

Polygonum cuspidatum, Japanese fleeceflower

This is an escaped ornamental that volunteers readily on spoil in LRA's 147, 125, 126,

127, and southward. It is very common in the Ohio River Valley.

Japanese fleeceflower is a large, robust, herbaceous perennial that grows to a height of 6 to 8 feet in one growing season. It dies back to the ground each year, and new growth arises from the root stalks and rhizomes. It is multistemmed and heavily branched and produces considerable amounts of seed. The foliage turns red in fall.

This species is of interest because it grows well on very acid mine spoil. Accession KY-795 was collected in Belmont County, Ohio, where it was thriving on spoil at a pH of 3.2. Sutton (see footnote 1) reports a survival rate of 37 percent for plantings of KY-795 on spoils at a pH of 2.5 and 3.6. Six years after planting the spoil pH was 3.5 and new plants had established from seed.

Good stands from direct seeding on very acid coal mine spoil are reported from Tennessee, Kentucky, and northwestern Pennsylvania.

CAUTION: From all indications, this species can become a pest. It seeds readily into open places. It should be used only on problem sites where it is already an escaped ornamental and a new planting will not contribute to its spread.

Polygonum cuspidatum v. compactum, dwarf Japanese fleeceflower

Dwarf Japanese fleeceflower is a low-growing herbaceous plant that is used commercially as an ornamental ground cover. It grows to a height of 18 to 30 inches, spreads by rhizomes, and has very attractive autumn foliage. This variety of fleeceflower is not as acid tolerant as Japanese fleeceflower but good stands can be established on acid spoil. More information on the use and adaptation of dwarf Japanese fleeceflower is available from the Quicksand Plant Materials Center, Quicksand, Ky.

Rumex acetosella, red sorrel

A perennial herb that grows 6 to 10 inches tall, red sorrel is common to the Appalachian region on infertile soils. In LRA's 126 and 127, it was the best native forb to provide cover on acid, low-fertility spoil.

Sanguisorba minor, salad burnet

Although this species is not common to the eastern part of the United States, good stands of salad burnet were established on slightly acid spoils by frost seedings and on compacted spoil if a seedbed was prepared. Stands seldom produced more than 30-percent cover but did persist nearly 5 years. Reseeding was very poor and stands did not perpetuate themselves. The plants lacked vigorous growth characteristics and usually succumbed to invading species.

Saponaria officinalis, bouncing bet

Bouncing bet is an escaped ornamental common to low-fertility waste areas in LRA 126S. Fall and spring seedings produced poor stands. Plants were not competitive with invading species. Best stands were on slightly acid spoil. New plants emerged over a 4-year period on one site but failed to produce seed.

Stellaria spp., chickweed

Only spring seedings were made. All plantings failed.

Tussilago farfara, coltsfoot

Coltsfoot, a common forb, invades most spoil areas that have limestone or other calcareous material in the overburden. It is a good indicator of slightly acid spoil.

Coltsfoot is broadleaved and seldom grows to a height of more than 10 to 12 inches. Seed matures early in spring and is readily dispersed by wind. Volunteer stands are open. On some fertile spoils, cover is 100 percent during the growing season but very little litter remains after the first frost.

In LRA 126S, locally collected seed was planted. Over a 2-year period stands failed to develop.

Species for specific uses

Plant materials are required for specific situations in stabilizing mine spoil. Some general indications of species adapted to specific uses are summarized in this section.

This is only a general summary and should not be used as a complete guide to selecting plants for revegetating mine spoil. The tables and text in this report provide specific information on the adaptation and comparative performance of species by LRA's and spoil groups.

Only common names are given here. Scientific names are provided in the tables, text, and index.

Temporary cover to provide quick stabilization of steep slopes and other highly erodible areas: *very acid spoils* (below pH 4.0)—weeping lovegrass; *acid and slightly acid spoils* (above 4.0)—ryegrass, weeping lovegrass, redtop, tall oatgrass, tall fescue; Korean lespedeza; sweetclover on spoils above pH 6.0.

Permanent cover that provides early stabilization with no maintenance: *very acid spoils* (below pH 4.0)—'Arnot' bristly locust; Japanese fleeceflower; 'Tioga' deertongue; *acid spoil* (pH from 4.0 to 5.4)—black locust, European black alder, Virginia pine, Japanese larch; 'Cardinal' autumn-olive, 'Arnot' bristly locust, indigobush; 'Tioga' deertongue, switchgrass; sericea lespedeza; flatpea above pH 4.8; *slightly acid spoil* (pH 5.5 to 7.0)—black locust, European black alder, Japanese larch; 'Cardinal' autumn-olive, 'Arnot' bristly locust, silver buffaloberry, indigobush; switchgrass, big bluestem, tall fescue, red fescue; crownvetch, 'Lathco' flatpea, sericea lespedeza; *alkaline spoil* (above pH 7.0)—black locust; Russian-olive, indigobush, 'Cardinal' autumn-olive; switchgrass, big bluestem, tall fescue; crownvetch, 'Lathco' flatpea.

Shrubs for wildlife food and cover: *very acid spoil* (below pH 4.0)—'Arnot' bristly locust; *acid and slightly acid spoil* (pH 4.0 to 7.0)—'Cardinal' autumn-olive, 'Rem Red' amur honeysuckle, Tatarian honeysuckle, silky dogwood, 'Natob' bicolor lespedeza, Japan lespedeza, shining sumac; *alkaline spoil* (above pH 7.0)—'Cardinal' autumn-olive, 'Rem Red' amur honeysuckle, Russian-olive.

Vines useful for reclamation of areas difficult to seed or plant: spoils above pH 6.0—kudzu.

Plants useful as barriers: spoils above pH 4.0—'Cardinal' autumn-olive, silver buffaloberry.

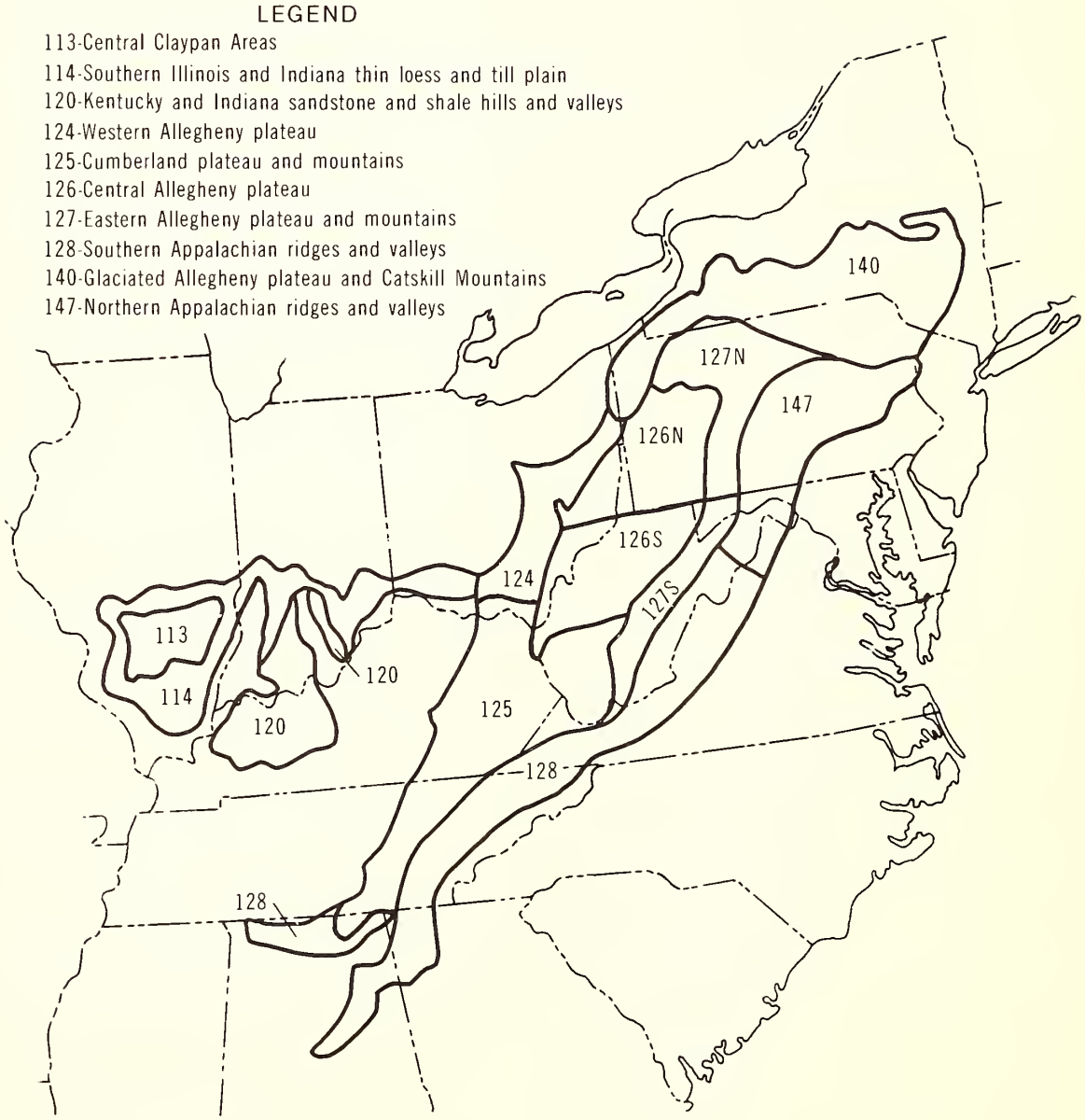
Plants useful for screening: white pine, red pine, Virginia pine; Norway spruce, amur privet, 'Cardinal' autumn-olive, silver buffaloberry for acid and slightly acid spoils.

Woody species adapted to direct seeding: black locust, Virginia pine; red oak if spot planted on acid and slightly acid spoil; 'Arnot' bristly locust for all spoil groups; Japan and 'Natob' bicolor lespedeza for acid and slightly acid spoil.

Woody plants least palatable to livestock and browsing animals: European black alder, sycamore; indigobush, fragrant sumac.

Plants with a tendency to spread on mine spoil; multiflora rose, Japanese fleeceflower, 'Cardinal' autumn-olive.

MAJOR LAND RESOURCE AREAS IN WHICH PLANTS WERE EVALUATED



Descriptions of land resource areas

LRA 113—Central Claypan Areas (Illinois)
11,000 square miles

Elevation and Topography: 500 to 600 feet, increasing gradually from south to north. These areas consist of nearly level to gently sloping silt-mantled old till plains.

Climate: Average annual precipitation—40 inches; about 60 percent falls during the freeze-free period. Average annual temperature—55° F. Average freeze-free period —180 to 190 days.

Soil: Most of the soils are Aqualfs that have deep, medium-textured surface layers, fine and moderately fine subsoils, mesic temperature regimes, and montmorillonitic mineralogy.

LRA 114—Southern Illinois and Indiana Thin Loess and Till Plain (Illinois, Indiana, and Ohio)
14,400 square miles

Elevation and Topography: 400 feet on valley floors to 1,200 feet on ridgetops, the ridgetops increasing in elevation from west to east.

Climate: Average annual precipitation—35 to 40 inches; highest in spring and early in summer and least from midsummer to autumn. Average annual temperature—53° to 58° F. Average freeze-free period—180 to 200 days.

Soil: Most of the soils are Aqualfs—deep, medium-textured soils that have mesic temperature regimes and mixed mineralogy. Moderately well drained and well drained Fragiudalfs (Ava, Cincinnati, and Rossmoyne series) are on gently sloping to strongly sloping side slopes; well-drained Hapludalfs (Hickory series) are on steeper slopes of the glacial till uplands; well-drained shallow Hapludolls (Fairmont series) formed in shaly limestone materials are on valley sides near the Ohio-Indiana state line.

LRA 120—Kentucky and Indiana Sandstone and Shale Hills and Valleys (Kentucky and Indiana)
11,200 square miles

Elevation and Topography: 400 feet on the lowest valley floors to about 800 feet on the highest ridgetops. The smoother parts of the gently rolling to hilly dissected sandstone and shale plateau have a thin to moderately thick loess cap. Local relief is mainly 100 to 200 feet, but some of the deeper valleys are several hundred feet below adjacent ridgetops. Strip mines, both operating and abandoned, are conspicuous features in many parts of the area.

Climate: Average annual precipitation—40 to 48 inches; fairly evenly distributed but slightly higher in spring and early summer and lowest from midsummer through autumn. Average annual temperature—55° to 58° F. Average freeze-free period—180 to 195 days.

Soil: Most of the soils are Udalfs that have fine-silty or fine-loamy particle size classes, mixed mineralogy, mesic soil temperature, and udic moisture regimes. The dominant great groups are Fragiudalfs (Grenada and Zanesville series) and Hapludalfs (Wellston and Frondorf series).

LRA 124—Western Allegheny Plateau (Ohio)
8,200 square miles

Elevation and Topography: 650 feet on the lowest valley floors to 1,300 feet at the highest ridgetops. The dissected sandstone plateau has narrow level valley floors, rolling ridgetops, and hilly to steep ridge slopes. Local relief is one to several hundred feet.

Climate: Average annual precipitation—40 to 45 inches; evenly distributed except for slight maximum in late spring and minimum in late autumn. Average annual temperature—48° to 55° F. Average freeze-free period —mainly 140 to 160 days but 180 days along the southern edge.

Soil: Most of the soils are Ochrepts, Udults, and Udalfs that have fine-loamy, loamy-skeletal, and fine particle size classes, mixed mineralogy, mesic soil temperature, and udic moisture regimes. Well-drained fine-loamy and loamy-skeletal Dystrochrepts (Muskingum and Dekalb series) are on sloping to steep areas. They formed in residuum derived from interbedded acid sandstone, siltstone, and shale. Well-drained, fine-loamy Hapludults (Gilpin, Trappist, and Latham series) on sloping to steep areas formed in residuum derived from acid siltstone, shale, and some sandstone.

LRA 125—Cumberland Plateau and Mountains (Kentucky, Tennessee, and West Virginia)
25,900 square miles

Elevation and Topography: 500 feet on the Ohio River flood plain to about 1,100 feet on nearby ridgetops; gradually rises to the Virginia-Kentucky border where local flood plains are about 1,500 feet and higher mountains are about 4,000 feet. The area is highly dissected, and topography is largely a series of long steep side slopes between narrow ridgetops or crests and narrow stream flood plains.

Climate: Average annual precipitation—about 46 inches, about 21 inches of which is during the growing season. Average annual temperature—about 55° F. Average annual freeze-free period—about 175 days. Snowfall is

quite variable but is estimated to average about 20 inches.

Soil: Most of the soils are Udults that have fine-silty, fine-loamy, and clayey particle size classes, mixed or siliceous mineralogy, mesic soil temperature, and udic moisture regimes. The dominant great group is Hapludults (Shelocta, Jefferson, Clymer, Gilpin, and Latham series). The deep Shelocta and Jefferson soils formed in loamy hillside creep or colluvium on mountain sides and coves. The Gilpin and Clymer soils formed in loamy residuum on side slopes and ridges. The Latham soils are on upper slopes or crests and formed in clayey shale residuum.

LRA 126—Central Allegheny Plateau (West Virginia, Pennsylvania, and Ohio) 19,400 square miles

Elevation and Topography: 600 feet on the lowest valley floors to 1,300 feet at the highest ridgetops. The dissected plateau is underlain by sandstones, siltstones, and shales and some layers of limestone.

Climate: Average annual precipitation—35 to 45 inches; somewhat unevenly distributed; highest in midsummer and lowest in autumn and early winter. Average annual temperature—40° to 55° F. Average freeze-free period —120 to 170 days.

Soil: Most of the soils are Udalfs, Udults, and Ochrepts. They are mostly well drained and moderately well drained, moderately deep and deep, medium- and fine-textured soils that have mesic temperature regimes and mixed mineralogy on uplands. Well-drained, medium-textured Hapludalfs (Westmoreland and Culleoka) are sloping to steep soils formed in material weathered from lime-influenced interbedded siltstones, shale, and fine-grained sandstone uplands. Well-drained, fine-textured Hapludalfs (Upshur) are sloping to steep soils formed in material weathered from lime-influenced shale on uplands. Moderately well drained, fine-textured Hapludalfs (Guernsey) are sloping to steep soils formed in material weathered from interbedded siltstone and shale with some limestone influence on upland benches. Well-drained Hapludults (Gilpin) are medium-textured, sloping to very steep soils formed in material weathered from acid siltstone, sandstone, and shale on uplands. Well-drained Dystrochrepts (Berks and Dekalb) are medium-textured, sloping to very steep soils formed in material weathered from acid sandstone, siltstone, and shale on uplands.

LRA 127—Eastern Allegheny Plateau and Mountains (Pennsylvania, West Virginia, and Maryland) 15,900 square miles

Elevation and Topography: 1,000 feet in the lowest valleys to 2,000 to 2,500 feet over much of the plateau top; mountains in the southeast 3,500 to 4,500 feet.

Climate: Average annual precipitation—40 to 56 inches; highest in spring, least in fall. Average annual temperature—45° to 52° F. Average freeze-free period—110 to 160 days, increasing from north to south.

Soil: Most of the soils in the area are Ochrepts, Udults, and Aquults that have mixed mineralogy, udic and aquic moisture regimes, and mesic temperature regimes. Nearly level to steep, moderately deep to deep, well-drained Dystrochrepts (Calvin, Dekalb, and Hazleton series) of major extent are loamy-skeletal soils formed in material weathered from acid sandstone, siltstone, and shale. These soils generally are on the plateau and the upper mountain slopes. Nearly level to gently sloping, well drained and moderately well drained, medium-textured Dystrochrepts (Pope and Philo series) of lesser extent formed in alluvium along streams and are subject to periodic stream overflow. Nearly level to steep, medium- to fine-textured, well drained to moderately well drained Hapludults (Clymer, Gilpin, and Wharton series) and Fragiudults (Cookport series) formed in material weathered from sandstone, siltstone, and shale. These soils generally are on the plateau although Gilpin soils commonly occur on the steep mountain slopes. Somewhat poorly drained, fine-textured, nearly level to sloping Ochraquults (Cavode series) formed in material weathered from shale.

LRA 128—Southern Appalachian Ridges and Valleys (Virginia, West Virginia, Tennessee, Georgia, and Alabama) 28,600 square miles

Elevation and Topography: 700 feet near the southern end to more than 2,000 feet in central Virginia. Some isolated linear mountain ridges rise to nearly 5,000 feet above sea level. The area consists of many parallel ridges, narrow intervening valleys, and large bodies of low, irregular hills. The ridges and valleys often have differences in elevation of 500 feet. The western side of the area, which is dominantly hilly to very steep, is rougher and much steeper than the eastern side, which is rolling and hilly.

Climate: Average annual precipitation—36 to 55 inches, increasing from north to south; highest in midwinter and midsummer and least in autumn. Average freeze-free period—170 to 210 days. Rainfall generally is adequate for crop production and to supply water for other needs. Short dry periods in the early part of summer occasionally reduce crop yields. Average annual temperature—from 60° to 55° F., decreasing from south to north.

Soil: Because of numerous geological formations, mass wasting of slopes, and stream action, there are many and often contrasting kinds of soils in this area. The soils are dominantly strongly acid and highly leached and have clay-enriched subsoils. They range from shallow on the sandstone and shale ridges to very deep in the valleys and in the large limestone formations. Udults dominate the area, but there is a sizable acreage of Ochrepts. Well-drained and often cherty Paleudults (Dunmore, Decatur, Dewey, Frederick, and Fullerton series) are on the numerous and extensive areas underlain by limestone that traverse the region in southwest-northeast direction.

LRA 140—Glaciated Allegheny Plateau and Catskill Mountains (New York and Pennsylvania) 27,400 square miles

Elevation and Topography: 500 to 1,000 feet on valley floors, 1,700 to 2,000 feet on plateau tops, and 3,500 feet or more in parts of the Catskills.

Climate: Average annual precipitation—30 to 40 inches; half or more falls during the growing season; winter precipitation is mostly snow. Average annual temperature—47° to 50° F. Average freeze-free period—110 to 160 days.

Soil: Most of the soils are Ochrepts—moderately deep to deep, somewhat stony, medium-textured soils that have mesic temperature regimes, mixed mineralogy, and fragipans. Nearly level to moderately sloping, moderately well drained Fragiochrepts (Mardin and Wellsboro series) and somewhat poorly drained Fragiaquepts (Volusia and Morris series) are on the till-mantled uplands; shallow and stony Dystrochrepts (Lordstown and Oquaga series) are steeper; deep, loamy, well-drained Dystrochrepts (Chenango series) are on outwash in the valleys.

LRA 147—Northern Appalachian Ridges and Valleys (Pennsylvania, Maryland, West Virginia, and Virginia) 15,700 square miles

Elevation and Topography: 400 to 1,000 feet in valleys and 1,200 to 2,500 feet on ridges and mountains; some mountain crests are 3,000 feet. Parallel sandstone and shale ridges are separated by narrow to moderately broad limestone and shale valleys. Ridges have hilly to steep slopes and narrow rolling crests; valleys are mainly undulating to rolling but are hilly locally.

Climate: Average annual precipitation—35 to 50 inches; highest in spring and summer and least in fall. Average annual temperature—47° to 55° F. Average freeze-free period—140 to 180 days.

Soil: The soil patterns in the area are complex. Most of the soils are Udalfs, Udults, and Ochrepts that have mixed mineralogy, udic and aquic moisture regimes, and mesic temperature. Nearly level to sloping, deep, well-drained, medium- to fine-textured Hapludalfs (Hagerstown, Duffield, Edom, and Washington series) are in the limestone valleys. Gently sloping to sloping, deep, well drained or moderately well drained, medium- to fine-textured Hapludults (Allenwood, Bedington, Frankstown, Mertz, and Murrill series), Fragiudults (Buchanan and Laidig series), and Paleudults (Frederick series) are on the lower footslopes of the ridges and in the valleys. Most of these soils formed in residuum, colluvium, or glacial till derived from limestone, cherty limestone, sandstone, and shale. Sloping to steep, well-drained, shallow to deep, medium-textured Dystrochrepts (Berks, Calvin, Dekalb, Hazleton, and Weikert series) are on the ridges and the more sloping areas in the valleys.

Performance code for trees used in table 1

LRA—Land resource area

Spoil groups

VA—very acid (below pH 4.0)
A—acid (pH 4.0 to 5.4)
SA—slightly acid (pH 5.5 or above)

Vigor

E—Excellent (2 to 3 feet annual height growth)
G—Good (1 to 2 feet annual height growth)
F—Fair (6 to 12 inches annual height growth)
P—Poor (growth nearly stopped)
O—Failed (plants dead or dying)
V—Performance too variable within or between plantings to evaluate.
— An underlined rating indicates outstanding erosion control value.

Number of plantings

* —Indicates ratings based on four or more plantings
″ —Indicates rating based on two to three plantings
—Absence of a symbol indicates only one planting

Age of planting

The number below the vigor rating indicates the age of the oldest planting evaluated. Age is significant with regard to yield, degree of cover, spreading, and persistence on the site.

Example

G* —The rating is based on four or more plantings that have good vigor; the oldest planting is 17 years old; the underline indicates that the species has outstanding erosion control value.
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Table 1.—Performance of trees within land resource areas according to spoil groups

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Acer negundo boxelder											F 10													
Acer rubrum red maple								G 17	G 11		F 8	G 5								G			G 11	
Acer saccharinum silver maple						G" 13			E" 11		G" 10													
Ailanthus altissima ailanthus								G		P" 10													P 11	
Albizia julibrissin silktree, mimosa											G* 10											O 2	P" 11	
Alnus glutinosa European black alder	O 3		F 5	F" 4	E" 10	G" 13		F" 10	F" 11	O 5	E* 8	G* 10	O 15	G" 13	G" 13	O 12	E* 12	E* 12	P" 8	V 13		P* 13	G* 16	
Alnus incana speckled alder											G 9		O" 15	G" 13	G" 13	O" 12	E" 12	G" 12	P" 13	P" 13		P" 13	G* 16	
Alnus rubra red alder											P 8													
Betula alleghaniensis yellow birch																	P 13			P 13				
Betula lenta sweet birch								F" 10									P" 13			G 13			G" 8	
Betula nigra river birch						G* 13		G* 10			G" 10						O 13							
Betula papyrifera paper birch											G* 10			P 20	G 25									
Betula populifolia gray birch														F 20	F" 25					G* 13				
Castanea mollissima Chinese chestnut			G 7			E 20					G 10			G" 15						G" 13				
Cornus florida flowering dogwood											F 10													

Table 1.—Performance of trees within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Cotinus obovatus smoketree											P 10													
Fraxinus americana white ash								G 11			F 10			F 11										
Fraxinus pennsylvanica green ash			G'' 13		P* 13	G* 13		G* 20	G* 11		P* 10			P'' 13	F'' 13					P 13		O 16	P 16	
Gleditsia triacanthos honeylocust											P'' 10				G 15									
Juglans nigra black walnut					G 8						P'' 8						P 10	P 10					P'' 8	
Juniperus communis common juniper											O 3													
Juniperus communis var. depressa dwarf common juniper											F 8													
Koelreuteria paniculata golden rain tree									P 20															
Larix decidua European larch									P 11		P'' 8	P 15	O 13	F'' 15	F'' 13				O'' 13	G* 13	F* 13		V'' 16	P 16
Larix x eurolepis 'Dunkfeld' hybrid larch												P 15	O 13	E'' 15	V'' 13	P 12	F 12			V 13		O 13	P 13	P 13
Larix leptolepis Japanese larch								E 10	P 11		P 8	F 15	O 13	E'' 20	G'' 25	O 15	F'' 15	P'' 15	F 13	G* 20	G 13		V 16	P 16
Liquidambar styraciflua sweetgum			E 8			G* 13		E 17	F'' 11		G 10		O 13		F 13			G 13	O 13	F'' 13			P 16	
Liriodendron tulipifera yellow poplar						G* 13		F 11	G 11		F'' 10			G 11			F 13						F'' 11	
Malus pumila apple															G 1			O 12					G 16	
Morus nigra mulberry											P 10													

Table 1.—Performance of trees within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Nyssa sylvatica blackgum											P 10													
Oxydendrum arboreum sourwood											G 10													
Paulownia tomentosa empress-tree																						O 2	F 2	
Picea abies Norway spruce								G" 10	G 11					F" 25	F 13				P 13	G* 13			F 8	
Picea pungens blue spruce														F 20										
Pinus banksiana jack pine						F" 13								G" 20	P" 8									
Pinus echinata shortleaf pine						F 13		F" 18			F 8	G 10		O" 15			F* 13						P 16	
Pinus mugo mugo pine								P 9	F		P 9		P 13	F 20	F 12			O 12	P 13	F" 13		P" 13	P" 13	
Pinus nigra Austrian pine								F 16	G 18		G" 10		F 8	G 8	G* 25								F 8	
Pinus pinaster Spanish pine																		O 13						
Pinus pungens table-mountain pine														F 25										
Pinus resinosa red pine						G 13		G 20					P 20	E" 25			F 13			G* 25			F" 16	
Pinus rigida pitch pine						P 13					P 8			G" 20	G 15					P" 13				
Pinus strobus white pine						G 13		E" 20	G" 18		G" 10		O 15	G 8	G* 20		G 13	F 12	P 13	G" 13			E* 20	
Pinus sylvestris Scotch pine					G			G" 8	F 18		G" 10		P	G	F"			G		G*			G"	

Table 1.—Performance of trees within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Pinus taeda loblolly pine											E'' 10	G 10		O 15			P 13						F 16	
Pinus thunbergii Japanese black pine												F 10	O 13	P'' 13	F'' 13			P 13		F'' 10			F'' 18	
Pinus virginiana Virginia pine											G'' 10	G 10	P 15	F 20	P* 8	P 13	G 13	F 13		P 13		P 18	F'' 18	
Platanus occidentalis American sycamore			G			G* 13			G'' 11		G'' 10		O 15	F'' 15		O 12	F* 13	F* 12	O 5	P'' 13			P'' 16	
Populus canescens curly poplar												F 10				O 12	G 13					O 18	G'' 18	
Populus deltoides eastern cottonwood			G 7			E 13					G 8	G 10	O 13	G'' 13	G 13	O 12	E'' 13	E'' 12		P 13		P 16	E'' 20	
Populus robusta hybrid poplar					G 8	O 13			P'' 11														P 13	
Populus sargentii plains cottonwood											P 13		O 15	P 15									P 13	
Populus sargentii x Norway hybrid cottonwood					F'' 15	O 13			P'' 11		G 10									E 13				
Populus sargentii x Siouxland Siouxland cottonwood						O 13								O 13			O 13							
Populus spp. species of cottonwood						E'' 13		E'' 10	E 10					E 20						E 13				
Prunus serotina black cherry								P 8									P 13						G 10	
Pseudotsuga menziesii Douglas-fir																				F 20				
Quercus acutissima sawtooth oak									P'' 18		P 8	G 15	O'' 15	P'' 15				F'' 12		F 19			G'' 19	
Quercus falcata southern red oak												O 3												

Table 1.—Performance of trees within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Quercus macrocarpa bur oak											F 10		O″ 15	F″ 15	F″ 15									
Quercus palustris pin oak											G 10													
Quercus robur English oak									P 11															
Quercus rubra northern red oak					P 15	G″ 13		V 20	G″ 18		F″ 10		O″ 15	G″ 20		O 12		G″ 12		G* 20			F 16	
Robinia pseudoacacia black locust			E 7		E 8	F 13		G″ 17	G* 11		G″ 10	G″ 20	P″ 15	F* 20	G* 20	P 15	G* 20	G* 20	P 13	F 13		P 16	G* 19	
Robinia pseudoacacia black locust (dominant stem)													P 15	F 15			G* 12	G* 12					E″ 18	
Sorbus alnifolia alternate leaf mountain-ash																	F 2							
Taxodium distichum baldcypress														P 15										
Tilia americana American basswood											F 8													
Ulmus pumila Siberian elm											G″ 10													

Performance code for shrubs, vines, and brambles used in table 2

LRA—Land resource area

Spoil groups

VA—very acid (below pH 4.0)
A—acid (pH 4.0 to 5.4)
SA—slightly acid (pH 5.5 or above)

Performance rating	*Plants evaluated for cover*	*Plants evaluated for special uses**
E	100-percent cover	Excellent
G	80- to 100-percent cover	Good
F	50- to 80-percent cover	Fair
P	25- to 50-percent cover	Poor
O	25-percent or less cover	Failed

V Performance too variable within or between plantings to rate.

— An underlined rating indicates outstanding erosion control value.

* Refers to their performance on spoil as compared to their expected performance on nonspoil sites.

Number of plantings

* —Indicates ratings based on four or more plantings
″ —Indicates rating based on two to three plantings
—Absence of a symbol indicates only one planting

Age of planting

The number below the performance rating indicates the age of the oldest planting evaluated.

Example

$\underline{\text{G}''}_{12}$ —Indicates the rating is based on two to three plantings that provide 80- to 100-percent cover; the oldest planting is 12 years old; the underline indicates that the species has outstanding erosion control value.

Table 2.—Performance of shrubs, vines, and brambles within land resource areas according to spoil groups

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Akebia quinata fiveleaf akebia			O'' 5			P				O 4													O 4	
Amorpha fruticosa indigobush								G 4		F 4	G 10	E 15	P 15	G 15		P 12	G 12	G'' 12	F 13	E 13		O'' 12	G* 16	
Amorpha glabra mountain indigo											G 8	G 15		G 10	G 10	O 12				G 13			F 12	
Ampelopsis brevipedunculata amur ampelopsis										P 4														
Aralia spinosa Hercules-club													P 15				P 13			P 13			P 18	
Aronia melanocarpa black chokeberry					F''				F 11															
Berberis koreana Korean barberry														G 20	G 25									
Berberis thunbergii barberry											F 10			F 20										
Campsis radicans common trumpetcreeper																							P'' 5	
Caragana arborescens pea-tree					P''						P 10						P 2							
Caragana microphylla littleleaf peashrub																	G 2							
Ceanothus americanus New Jersey tea																							P 2	
Celastrus scandens American bittersweet														O 13										
Cercis canadensis eastern redbud			F''								P 8													
Clematis spp. clematis											O 5													

Table 2.—Performance of shrubs, vines, and brambles within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Colutea arborescens bladder-senna											P 8	F 15	O 13	O 13		O 13	P 13	P 13		O 13		O 13	P 18	
Comptonia peregrina sweetfern																			O 15	O 15				
Cornus amomum silky dogwood									P 11		F 10	P 10	O 15	P 15				F 13	P'' 13	F'' 13			O 13	F'' 19
Cornus racemosa graystem dogwood												F 6					P 13							P 18
Cornus stolonifera red-osier dogwood											F 8	F 10	O 15	G'' 13				P 13	O 13	F'' 13			P 16	
Corylus americana hazelnut									G					F'' 18										
Crataegus spp. hawthorn															G 20									
Cytisus ratisbonensis																	O 15						O 15	
Cytisus scoparius Scotch broom								F 15			P 10			O'' 10		O'' 12	P'' 12	O'' 12		O 13			P'' 15	
Cytisus supinus big flower broom																							P'' 15	
Diervilla lonicera dwarf bush honeysuckle																							O 15	
Elaeagnus angustifolia Russian-olive			G''								F 10	P 15	O 15	F 15	E'' 20		O 20	F 20					O'' 20	
Elaeagnus commutata silverberry															P 20									
Elaeagnus multiflora cherry elaeagnus											G 10													
Elaeagnus pungens thorny elaeagnus											P 10													

Table 2.—Performance of shrubs, vines, and brambles within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Elaeagnus umbellata autumn-olive		F 5	G* 13			E 13		E* 17	E* 11	O 4	G* 9	E* 15	P 15	E* 20	E* 15	P* 15	E* 15	E* 12	P 13	E" 13		P 15	E* 19	E* 15
Forsythia x intermedia 'Arnold's' dwarf forsythia											O 15							P 15	O 15	O 15			O 15	
Hibiscus syriacus rose of sharon											P 10													
Hippophae rhamnoides seabuckthorn													O 5						O 4	F 3				
Hydrangea quercifolia oakleaf hydrangea											F 10													
Indigofera kirilowi Kirilow indigo													O 15	P" 15								O 15	O" 15	
Indigofera pseudotinctoria false anil indigo												P 10				O 4		O 4					O 4	
Lespedeza bicolor bicolor lespedeza								G" 17			G" 17			F" 20		O 10	F 10	G 10	O 15	P" 15			G" 18	
Lespedeza bicolor 'Natob' bicolor lespedeza								F 17			O 13			P 15			F" 15		O 15	G 15		O 13	F" 13	
Lespedeza japonica Japan lespedeza			O 8					G 17			G" 10	G 10		O 15			G 15			O 15			P 13	
Ligustrum amurense amur privet									G" 11		G" 10			G 20		O 12		E 12					G" 12	
Lonicera maackii 'Rem Red' amur honeysuckle								P" 2	F" 18		F" 9			F 10	G" 25	O 12	G* 12	G" 12		G 13		O 13	G" 16	
Lonicera tatarica Tatarian honeysuckle									G 18		F" 10			F" 20				G" 12		F 13			G" 16	
Maclura pomifera osage-orange														G 20	F 25									
Malus baccata Siberian crabapple								E 4	G 6									G 12					G 16	

Table 2.—Performance of shrubs, vines, and brambles within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Malus floribunda Japanese flowering crabapple											G 10		P 13	G'' 13			G 13			P'' 13			G'' 16	
Malus hupehensis tea crabapple														G 13			G 13						F 16	
Malus sieboldi toringo crabapple											G 10			G 13			G 13						G 16	
Malus spp. species of crabapple								G 17	G 11		E 10			G'' 20	G* 25		G 13							
Malus zumi 'Bobwhite' crabapple									G'' 11					G 13									G 16	
Myrica pensylvanica bayberry														G 20			F 10							
Photinia villosa oriental photinia							O	F																
Prinsepia sinensis cherry prinsep											P 10	P 15	O 13	O 13									O'' 10	
Prunus besseyi western sand cherry					G* 5																			
Prunus spinosa blackthorn sloe												P 15	O 13	O 13									P 18	
Pueraria lobata kudzu			E			E						E 15					O* 15	E'' 20					E 18	
Quercus pumila 'Ware' runner oak											P 9									O 4				
Rhamnus cathartica European buckthorn																				O 4				
Rhododendron maximum rosebay rhododendron											G 10													
Rhus aromatica fragrant sumac											F'' 8		P 13	G'' 6		O 12	G 8	F 13	O 13	P'' 13			G'' 6	

Table 2.—Performance of shrubs, vines, and brambles within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Rhus copallina shining sumac													P 15	F″ 6		P″ 12	G″ 8	G″ 13	P 13	G″ 13			G″ 13	
Rhus glabra smooth sumac														P 6			G 16							
Rhus typhina staghorn sumac														P 6										
Robinia fertilis 'Arnot' bristly locust		E* 7			E* 8			G 6	E 18	P	E* 9		P 15	E* 15	E* 15	P 12	E* 12	E* 13	P″ 13	G″ 13			E* 16	
Rosa multiflora multiflora rose			G 7			G″ 8		G 4					O 15	G 15	G″ 15			G 18					G″ 18	
Rosa rugosa rugosa rose											P″ 10		O 13	P 13			F 13	F 13	O 13				F 13	
Rosa virginiana Virginia rose																							F 13	
Rosa wichuraiana memorial rose		F 10	G″ 7		F″ 8	G 13		G 17	F″ 15		F 10		O″ 13	F 15	F″ 15		G 15	E″ 13	P″ 13	G″ 13			F″ 19	
Rubus allegheniensis wild blackberry																	O 4	O 4						
Rubus hispidus dewberry																	O 4	O 4						
Rubus occidentalis wild raspberry																	O 4	O 4						
Rubus parviflorus trailing raspberry		P 7			P″ 8	P			P 18	O 4		P 10			O 10		O 20			O 13			O 20	
Rubus pungens trailing raspberry												P 10			O 10		O 20			O 10			O 20	
Salix interior sandbar willow			P* 7		O″ 10																			
Salix purpurea purpleosier willow			P″ 5	O 5		P″ 13		P 17	P 11					G 15		O 15	G 15	F 15	O 13	G 13			E″ 19	

Table 2.—Performance of shrubs, vines, and brambles within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Salix purpurea var. gracilis slender willow			P'' 7	P 2		P'' 5			P'' 11															
Salix purpurea var. nana dwarf willow											O 10													
Shepherdia argentea russet buffaloberry								G 17	G 11						E 25									
Spiraea tomentosa hardhack													P 13					O 12	P 13			O 10	P 10	
Symphoricarpos orbiculatus coralberry											P 10		O 4	P 4										
Tamarix parviflora tamarisk											F 10													
Vaccinium spp. blueberry											F 10													
Viburnum dentatum arrowwood											P 10			G 20	G 18									
Viburnum tomentosum doublefile viburnum											F 10													
Viburnum trilobum American cranberrybush														G 20	G 25									
Vitis riparia riverbank grape														P 10	O 10								P'' 13	
Vitis rotundifolia muscadine grape					G 4																			
Vitis spp. grape			P'' 10		P																			
Vitis vulpina frost grape														P 13										

Performance code for grasses used in table 3

LRA—Land resource area

Spoil groups

VA—very acid (below pH 4.0)
A—acid (pH 4.0 to 5.4)
SA—slightly acid (pH 5.5 or above)

Performance rating	*Plants evaluated for cover*	*Plants evaluated for special uses**
E	100-percent cover	Excellent
G	80- to 100-percent cover	Good
F	50- to 80-percent cover	Fair
P	25- to 50-percent cover	Poor
O	25-percent or less cover	Failed

V Performance too variable within or between plantings to rate.

— An underlined rating indicates outstanding erosion control value.

* Refers to their performance on spoil as compared to their expected performance on nonspoil sites.

Number of plantings

* —Indicates ratings based on four or more plantings
″ —Indicates rating based on two to three plantings
—Absence of a symbol indicates only one planting

Age of planting

The number below the performance rating indicates the age of the oldest planting evaluated.

Example

$\frac{G''}{12}$ —Indicates rating based on two to three plantings that provide 80- to 100-percent cover; the oldest planting is 12 years old; the underline indicates that the species has outstanding erosion control value.

Table 3.—Performance of grasses within land resource areas according to spoil groups

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Agropyron desertorum crested wheatgrass											O 10		O 10	O 10	O 10		O 10	O 10	O 10	O" 10	O 10		O" 10	
Agropyron intermedium intermediate wheatgrass													O 10	O 10	O 10		O 10	O" 10		O 10	P 13		O 10	
Agropyron repens quackgrass											O 2						O 2	O 2						
Agrostis alba redtop								O 4			F" 8	F" 8		O 8				O 10		P 8			P 8	
Alopecurus arundinaceus 'Garrison' creeping foxtail											O" 2	O" 4					O" 4							
Alopecurus pratensis meadow foxtail																	O" 4		O 8	O 8				
Andropogon caucasicus caucasian bluestem										O 7	P 7						O 8			O 8			O 8	
Andropogon gerardi big bluestem											G" 10	F" 4			P 8		P" 8			G* 10			V" 8	
Andropogon ischaemum yellow bluestem																							O** 8	
Andropogon scoparius little bluestem											F 10	G 17		O" 15			O* 8	P 3		F 3			O" 18	
Andropogon virginicus broomsedge														O 8			O 8						O 8	
Aristida spp. three-awn																	O 8						O 8	
Arrhenatherum elatius tall oatgrass										P 3	O" 10	P" 4	O 15	O 15			O 8	O 13		O 10	O 10		P" 8	
Bouteloua curtipendula side-oats grama															O 8		O" 8	O" 8					O" 16	
Bromus arvensis field brome										O" 4	P" 4												O 8	

Table 3.—Performance of grasses within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Bromus erectus meadow brome			P 1			P 1																		
Bromus inermis smooth brome			G* 5											O 8		O 8	O 8	O 8		O 8				
Buchloe dactyloides buffalograss															O 8		O'' 8	O'' 8					O 8	
Calamovilfa longifolia prairie sandreed																			O 4	G 3				
Cenchrus setigerus sandbur																							O 2	
Cynodon dactylon bermudagrass										O'' 3	P* 4	P 4												
Dactylis glomerata orchardgrass									G 6	O'' 2	P'' 4			P 10	F 10		F* 10	F* 10		P 8			F 8	P 13
Danthonia spicata poverty oatgrass																						O 4	O 4	
Digitaria spp. crabgrass																O	O		O					
Elymus giganteus mammoth wildrye											O'' 2	O'' 2											G 3	
Elymus triticoides creeping wildrye																						O 3	O 8	
Elymus virginicus Virginia wildrye																							O 3	
Eragrostis curvula weeping lovegrass								F		O'' 2	G* 2	G'' 2	G 2	G 2			F 2	F 2		O 2	O 2	O 2	G'' 2	
Eragrostis ferruginea Korean lovegrass								F			V'' 2		O 2	G 2			G 2					P'' 5	F'' 2	
Eragrostis trichodes sand lovegrass		G	G																					

Table 3.—Performance of grasses within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Festuca arundinacea tall fescue		E* 2	E* 5							F* 3	G" 10	G 20		G 15	G 15		O" 10	O 13	O 13	G 13			G	G
Festuca ovina duriuscula hard fescue		O" 2																						
Festuca rubra red fescue													O 8	P 8		O 10			O 10	F 10			F 10	
Hordeum bulbosum bulbous barley														O 2						O 2			O 2	
Lolium perenne perennial ryegrass											G" 2	G" 2	O 1	F 2	F 2	O 2	F 2	F 2	O 2	G 2		O 2	P 2	
Miscanthus sinensis Chinese silvergrass											F 8					P 13	G* 13						G" 18	
Panicum amarulum coastal panicgrass								G 3			G 17			P 10	P 10					O 8			F 16	
Panicum amarum bitter panicum														P 10	P 10		P" 10			O 8			P 18	P 18
Panicum anceps beaked panicum											O 4	O 4			O 5		P 10	O 5		P 8			P 5	
Panicum clandestinum deertongue		E 2	G" 5		G 2					F 3	G 10		P" 6	O 15		G 13	G" 13		V" 8	G* 8		P 10	V* 18	
Panicum virgatum switchgrass			F" 7			G* 7		G" 17		O 2	G" 10	E 10	P 6	G" 15	G" 15		G" 13	V 13		F" 3	G" 8		V 8	G" 18
Pennisetum alopecuroides Chinese pennisetum															O 2								O 2	
Phalaris arundinacea reed canarygrass										O" 4	P" 4	G 10		F 8			E" 10			G 13			G" 18	
Phalaris arundinacea var. picta ribbongrass																	O 10						O 10	
Phleum pratense timothy											G 2			F 10	F 10			P" 10		F" 8	F" 10			

Table 3.—Performance of grasses within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Poa bulbosa bulbous bluegrass																		O 5						
Poa compressa Canada bluegrass															O 12			O 4		O 4			O 4	
Poa pratensis Kentucky bluegrass																			O 4	P 8		O 4	P 8	
Setaria spp. bristlegrass																							O* 4	
Sorghastrum nutans indiangrass											P'' 10		O 10	F'' 10			P'' 10	V 10	O 5	F* 5	F 5		V* 18	O 18
Tridens flavus purpletop											P 4			O 10						P 16	O 16		P 18	
Tripsacum dactyloides eastern gamagrass												F 10			P 10					F 10			G'' 18	

Performance code for legumes used in table 4

LRA—Land resource area

Spoil groups

VA—very acid (below pH 4.0)
A—acid (pH 4.0 to 5.4)
SA—slightly acid (pH 5.5 or above)

Performance ratings	*Plants evaluated for cover*	*Plants evaluated for special uses**
E	100-percent cover	Excellent
G	80- to 100-percent cover	Good
F	50- to 80-percent cover	Fair
P	25- to 50-percent cover	Poor
O	25-percent or less cover	Failed

V Performance too variable within or between plantings to rate.

— An underlined rating indicates outstanding erosion control value.

* Refers to their performance on spoil as compared to their expected performance on nonspoil sites.

Number of plantings

* —Indicates ratings based on four or more plantings
″ —Indicates rating based on two to three plantings
—Absence of a symbol indicates only one planting

Age of planting

The number below the performance rating indicates the age of the oldest planting evaluated.

Example

$\underline{\text{G″}}$ —Indicates the rating is based on two to three
12 plantings that provide 80- to 100-percent cover; the oldest planting is 12 years old; the underline indicates that the species has outstanding erosion control value.

Table 4.—Performance of legumes within land resource areas according to spoil groups

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Astragalus cicer cicer milkvetch																				P 4				
Astragalus falcatus sickle pod milkvetch																				P 4				
Astragalus glycyphyllos milkvetch																				O 4				
Baptisia australis blue wild indigo																				F 4				
Cassia fasiculata partridge pea						F 5		O 4			P'' 3	F'' 3		O 4										
Coronilla varia 'Chemung' crownvetch			E'' 5		G 5					O 10	E'' 10	E* 15		G 10	E* 15		V* 12	E* 12		E* 13	E 13		E* 18	E 18
Coronilla varia 'Emerald' crownvetch		F'' 5	G'' 2												E 10			E 12						
Desmodium canadense Canada tickclover																							O 4	
Desmodium intortum																							O 4	
Lathyrus sylvestris 'Lathco' flatpea						F 5				F 3	E* 10		P 6	G* 15	F 10		V'' 12	E'' 12		G'' 13	G 13	O 13	G 8	
Lespedeza capitata roundhead lespedeza																							O 4	
Lespedeza cuneata sericea lespedeza			G'' 5			G 5		F'' 17	P 17	O'' 4	G* 10	G* 10	O 13	P* 13	P 15	O 4	V* 12	F* 12	O 4	F'' 12		O 5	V* 16	
Lespedeza daurica daurica lespedeza		P 5	G'' 5		P 5			P 6			P'' 7	P'' 2												
Lespedeza daurica var. shimadai prostrate lespedeza		F	E'' 5		F 3	V'' 5								O 13						O 13			O 12	O 12
Lespedeza hedysaroides rush lespedeza									G 4						P 13					P 13		O 8	P 8	

Table 4.—Performance of legumes within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Lespedeza intermedia wand lespedeza																								P 8
Lespedeza pilosa																								O 8
Lespedeza stipulacea Korean lespedeza		P 2	P 5					O 4	G 4	O" 4	V" 10			O								O 2	O 8	
Lespedeza striata annual lespedeza																							O 8	
Lespedeza tomentosa wooly lespedeza					F" 5																			
Lespedeza virgata 'Ambro' virgata lespedeza										O" 4	P" 4												O 8	
Lotus corniculatus birdsfoot trefoil		F 6	G" 5								P 10	F 10	O 12	F 12	P 10		F 12	G 12		G" 10	G 5	O 4	P 8	P 10
Lotus siliquosus big trefoil																							O 4	
Lotus tenuis narrowleaf trefoil			F 7				O 4				P 10	F 10		P" 13	P 13		P 12	P 13		P" 13	O 10	O 4	P 8	P 10
Medicago hispida California burclover																							O 4	
Medicago orbicularis button medic																							O 4	
Medicago sativa alfalfa			G" 5			G			G		V 4				P 13								O 8	
Medicago scutellata snail medic																							O 4	
Melilotus alba white sweetclover			G			G			G 4	O 4	P" 4	F" 4		O" 2	O" 13		O" 13	O" 13					O 10	O 10
Melilotus alba var. annua Hubam sweetclover			G 5											O 4	O 4									

Table 4.—Performance of legumes within land resource areas according to spoil groups—continued

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Onobrychis viciaefolia sainfoin											P 2	P 2												
Trifolium alexandrinum berseem or Egyptian clover																	O 4							O 4
Trifolium fragiferum strawberry clover																		O 8					O 8	
Trifolium hirtum rose clover																		O 8					O 8	
Trifolium hybridum alsike clover								P 4	G 4		P" 3	P" 3		P 4	G 4			O 8					O 8	
Trifolium medium zigzag clover											G" 10							O 8					O 2	
Trifolium pratense red clover											O 10	O 10						O 8		F 2			P 2	
Trifolium repens ladino clover																		O 8					O 8	
Vicia cracca bird vetch															O 13			P 13						

Performance code for forbs used in table 5

LRA—Land resource area

Spoil groups

VA—very acid (below pH 4.0)
A—acid (pH 4.0 to 5.4)
SA—slightly acid (pH 5.5 or above)

Performance rating	*Plants evaluated for cover*	*Plants evaluated for special uses**
E	100-percent cover	Excellent
G	80- to 100-percent cover	Good
F	50- to 80-percent cover	Fair
P	25- to 50-percent cover	Poor
O	25-percent or less cover	Failed

V Performance too variable within or between plantings to rate.

— An underlined rating indicates outstanding erosion control value.

* Refers to their performance on spoil as compared to their expected performance on nonspoil sites.

Number of plantings

* —Indicates ratings based on four or more plantings
″ —Indicates rating based on two to three plantings
—Absence of a symbol indicates only one planting

Example

$\frac{G''}{12}$ —Indicates rating based on two to three plantings that provide 80- to 100-percent cover; the oldest planting is 12 years old; the underline indicates that the species has outstanding erosion control value.

Table 5.—Performance of forbs within land resource areas according to spoil groups

Species	114			120			124			125			126N			126S			127N			127S		
	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA	VA	A	SA
Ambrosia artemisiifolia ragweed																		O 12			O 4		O 4	
Carex spp. sedge																							G 18	
Chenopodium album lambsquarters																		O 12					O 4	
Desmanthus illinoensis Illinois bundleflower								O 4						O 4										
Lactuca spp. prickly lettuce																		O 12					O 4	
Liriope graminifolia lilyturf															O 12			O 2			O 2	O 2	O 2	
Phytolacca americana pokeberry														O 5	O 5			O 12		O 5	O 5	O 4	O 4	
Plantago lanceolata buckhorn plantain																		O 12				O 4	O 4	
Polygonum cuspidatum Japanese fleeceflower				P 2						P" 3	G" 10		F" 7	G" 7	P 15	F 8		G 12	P 13	G 13			G 15	G 15
Polygonum cuspidatum var. compactum dwarf Japanese fleeceflower				P 2						P" 3	G 8													
Polygonum persicaria spotted ladysthumb																		O 12	O 4	O 4			O 4	
Rumux acetosella red sorrel																		P 4	F 4				O 10	
Sanguisorba minor salad burnet														O 5	P 5	O 5	O 15	P 13		P 13		O 4	O 16	
Saponaria officinalis bouncing bet																	O 4	O 4		O 4			O 4	P 4
Stellaria spp. chickweed																							O 4	O 4
Tussilago farfara coltsfoot																		P 12						P 4

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rubra Bong.	red alder	——	1
Alopecurus			
arundinaceus Poir.	'Garrison' creeping foxtail	——	3
pratensis L.	meadow foxtail	——	3
Ambrosia			
artemisiifolia L.	ragweed	37	5
Amorpha			
fruticosa L.	indigobush	15	2
glabra Desf. ex Poir.	mountain indigo	15	2
Ampelopsis			
brevipedunculata (Maxim.) Trautv.	amur ampelopsis	——	2
Andropogon			
caucasicus Trin.	caucasian bluestem	25	3
gerardi Vitman	big bluestem	26	3
ischaemum L.	yellow bluestem	——	3
scoparius Michx.	little bluestem	26	3
virginicus L.	broomsedge	26	3
Aralia			
spinosa L.	hercules-club	16	2
Aristida			
spp.	three-awn	26	3
Aronia			
melanocarpa (Michx.) Ell.	black chokeberry	——	2
Arrhenatherum			
elatius (L.) Presl.	tall oatgrass	26	3
Astragalus			
cicer L.	cicer milkvetch	32	4
lalcatus Lam.	sickle pod milkvetch	32	4
glycyphyllos L.	milkvetch	32	4
Baptisia			
australis (L.) R. Br.	blue wild indigo	——	4
Berberis L.			
koreana Palib.	Korean barberry	16	2
thunbergii	barberry	16	2
Betula			
alleghaniensis Britton	yellow birch	8	1
lenta L.	sweet birch	8	1
nigra L.	river birch	8	1
papyrilera Marsh	paper birch	8	1
populifolia Marsh	gray birch	8	1

Scientific name	Common name	Page	Table
Bouteloua			
curtipendula (Michx.) Torr.	side-oats grama	—	3
Bromus spp.	bromegrass	26	—
anatolicus Boiss. & Heldr.		—	—
arvensis L.	field brome	—	3
auleticus Trin. ex Nees		—	—
brachystachys Hornung		—	—
breviaristatus Buckl.	slimeleaf brome	—	—
brizaeformis Fisch. & Mey.	rattlesnake brome	—	—
carinatus Hook & Arn.	California brome	—	—
commutatus Schrad.	hairy chess	—	—
erectus Huds.	meadow brome	—	—
haenkeanus Kunth		—	—
inermis Leyss.	smooth brome	—	3
intermedia Guss		—	—
japonicus Thunb.	Japanese chess	—	—
macrostachys Desf.	Mediterranean brome	—	—
mollis L.	soft chess	—	—
pseudoanthoniae Drobov	false oatgrass	—	—
secalinus Bieb.	chess	—	—
squarrosus L. (Gmel.)		—	—
valdivianus Phil.		—	—
willdenowii Kunth	rescue grass	—	—
Buchloe			
dactyloides (Nutt.) Engelm.	buffalograss	—	3
Calamovilfa			
longifolia (Hook.) Scribn.	prairie sandreed	—	3
Campsis			
radicans (L.) Seem.	common trumpet-creeper	—	2
Caragana			
arborescens Lam.	pea-tree	—	2
microphylla Lam.	littleleaf peashrub	—	2
Carex			
spp. L.	sedges	37	5
Cassia			
fasciculata Michx.	partridge pea	32	4
Castanea			
mollissima Blume	Chinese chestnut	8	1
Ceanothus			
americanus L.	New Jersey tea	—	2
Celastrus			
scandens L.	American bittersweet	—	2
Cenchrus			
setigerus Vahl.	sandbur	—	3
Cercis			
canadensis L.	eastern redbud	—	2
Chenopodium			
album L.	lambsquarters	—	3
Clematis			
spp. L.	clematis	—	2
Colutea			
arborescens L.	bladder-senna	16	2
Comptonia			
peregrina (L.) Coult.	sweetfern	—	2
Cornus			
amomum Mill.	silky dogwood	16	2
florida L.	flowering dogwood	—	1
racemosa Lam.	graystem dogwood	16	2
stolonifera Michx.	red-osier dogwood	16	2

Scientific name	Common name	Page	Table
Coronilla			
varia L.	crownvetch	32	4
Corylus			
americana Walt.	hazelnut	——	2
Cotinus			
obovatus Raf.	smoketree	——	1
Crataegus			
spp. L.	hawthorn	——	2
Cynodon			
dactylon (L.) Pers.	bermudagrass	27	3
Cytisus			
ratisbonensis Schaeff.		17	2
scoparius (L.) Link	Scotch broom	17	2
supinus L.	big flower broom	17	2
Dactylis			
glomerata L.	orchardgrass	27	3
Danthonia			
spicata (L.) Beauv.	poverty oatgrass	——	3
Desmanthus			
illinoensis (Michx.) MacMill.	Illinois bundleflower	37	5
Desmodium			
canadense (L.) DC.	Canada tickclover	——	4
intortum (Mill.) Urban		——	4
Diervilla			
lonicera Mill.	dwarf bush honeysuckle	——	2
Digitaria spp.	crabgrass	27	3
argyrograpta (Nees) Stapf		——	——
eriantha Steud.		——	——
gazensis Rendle		——	——
iburua Stapf.		——	——
kilimandscharica Mez.		——	——
milanjiana (Rendle) Stapf		——	——
pentzii Stent		——	——
setivalva Stent		——	——
swazilandensis Stent		——	——
Elaeagnus			
angustifolia L.	Russian-olive	17	2
commutata Bernh.	silverberry	17	2
multiflora Thunb.	cherry elaeagnus	17	2
pungens Thunb.	thorny elaeagnus	17	2
umbellata Thunb.	autumn-olive	17	2
Elymus			
giganteus Vahl.	mammoth wildrye	27	3
triticoides Buckl.	creeping wildrye	27	3
virginicus v. glabriflorus (Vasey) Bush	Virginia wildrye	27	3
Eragrostis			
curvula (Schrad.) Nees	weeping lovegrass	27	3
ferruginea (Thunb.) Beauv.	Korean lovegrass	27	3
trichodes (Nutt.) Wood	sand lovegrass	27	3
Festuca			
arundinacea Schreb.	tall fescue	27	3
ovina duriuscula (L.) Koch	hard fescue	——	3
rubra L.	red fescue	28	3
Forsythia			
x intermedia Zab.	'Arnold's' dwarf forsythia	——	2
Fraxinus			
americana L.	American or white ash	8	1
pennsylvanica Marsh	green ash	8	1
Gleditsia			
triacanthos L.	honeylocust	——	1
Hibiscus			
syriacus L.	rose of sharon	——	2

Scientific name	Common name	Page	Table
Hippophae			
rhamnoides Pursh.	seabuckthorn	—	2
Hordeum			
bulbosum L.	bulbous barley	—	3
Hydrangea			
quercifolia Bartr.	oakleaf hydrangea	—	2
Indigofera			
kirilowi Maxim ex Palib	Kirilow indigo	—	2
pseudotinctoria Matsum.	false anil indigo	—	2
Juglans			
nigra L.	black walnut	9	1
Juniperus			
communis L.	common juniper	—	1
communis var. depressa Pursh	dwarf common juniper	—	1
Koelreuteria			
paniculata Laxm.	golden rain tree	—	1
Lactuca			
spp.	prickly lettuce	37	5
Larix			
decidua Mill.	European larch	9	1
x eurolepis A. Henry.	'Dunkfeld' hybrid larch	9	1
leptolepis Murr.	Japanese larch	9	1
Lathyrus			
sylvestris L.	'Lathco' flatpea	34	4
Lespedeza			
bicolor Turcz.	bicolor lespedeza	18	2
bicolor Turcz.	'Natob' bicolor lespedeza	18	2
capitata Michx.	roundhead lespedeza	—	4
cuneata (Dumont) G. Don	sericea lespedeza	34	4
daurica Schindl.	daurica lespedeza	36	4
daurica var. schimadai Matsamune	prostrate lespedeza	36	4
hedysaroides (Pall.) Kitagawa	rush lespedeza	—	4
intermedia (Wats.) Britt.	wand lespedeza	—	4
japonica L. H. Bailey	Japan lespedeza	18	2
pilosa (Thunb.) Sieb. & Zucc.		—	4
stipulacea Maxim.	Korean lespedeza	36	4
striata (Thunb.) H. & A.	annual lespedeza	—	4
tomentosa Siebold ex Maxim.	wooly lespedeza	—	4
virgata (Thunb.) DC. Prod.	'Ambro' virgata lespedeza	—	4
Ligustrum			
amurense Carr.	amur privet	18	2
Liquidambar			
styraciflua L.	sweetgum	9	1
Liriodendron			
tulipifera L.	yellow poplar	10	1
Liriope			
graminifolia (L.) Baker	lilyturf	37	5
Lolium			
perenne L.	perennial ryegrass	28	3
Lonicera			
maackii Maxim.	'Rem Red' amur honeysuckle	18	2
tatarica L.	Tatarian honeysuckle	18	2
Lotus			
corniculatus L.	birdsfoot trefoil	36	4
siliquosus L.	big trefoil	—	4
tenuis Waldst. & Kit.	narrowleaf trefoil	36	4
Maclura			
pomifera (Raf.) Schneid.	osage-orange	19	2

Scientific name	Common name	Page	Table
Malus			
baccata (L.) Borkh.	Siberian crabapple	—	2
floribunda Sieb. ex Van Houtte	Japanese flowering crabapple	—	2
hupehensis (Pamp.) Rehd.	tea crabapple	—	2
sieboldi (Reg.) Rehd.	toringo crabapple	—	2
pumila Mill.	apple	—	1
spp.	crabapples	19	2
zumi (Mats.) Rehd.	'Bobwhite' crabapple	—	2
Medicago			
hispida Gaertn.	California burclover	—	4
orbicularis (L.) Bartalina	button medic	—	4
sativa L.	alfalfa	36	4
scutellata (L.) Mill.	snail medic	—	4
Melilotus			
alba Desr.	white sweetclover	37	4
alba var. annua Coe.	Hubam sweetclover	37	4
Miscanthus			
sinensis Anderss.	Chinese silvergrass	29	3
Morus			
nigra L.	mulberry	—	1
Myrica			
pensylvanica Loisel.	bayberry	—	2
Nyssa			
sylvatica Marsh.	blackgum	—	1
Onobrychis			
viciaefolia Scop.	sainfoin	—	4
Oxydendrum			
arboreum (L.) DC.	sourwood	—	1
Panicum			
amarulum Hitch. & Chase	coastal panicgrass	29	3
amarum Ell.	bitter panicum	29	3
anceps Michx.	beaked panicum	—	3
clandestinum L.	deertongue	29	3
virgatum L.	switchgrass	30	3
Paulownia			
tomentosa (Thunb.) Sieb. & Zucc.	empress-tree	—	1
Pennisetum			
alopecuroides (L.) Spreng.	Chinese pennisetum	—	3
Phalaris			
arundinacea L.	reed canarygrass	31	3
arundinacea var. picta L.	ribbongrass	—	3
Phleum			
pratense L.	timothy	31	3
Photinia			
villosa (Thunb.) DC.	oriental photinia	—	2
Phytolacca			
americana L.	pokeberry	37	5
Picea			
abies (L.) Karst	Norway spruce	10	1
pungens Engelm.	blue spruce	10	1
Pinus			
banksiana Lamb.	jack pine	10	1
echinata Mill.	shortleaf pine	11	1
mugo Turra.	mugo pine	—	1
nigra Arnold	Austrian pine	11	1
pinaster Ait.	Spanish pine	11	1
pungens Lamb.	table-mountain pine	11	1
resinosa Ait.	red pine	11	1
rigida Mill.	pitch pine	—	1
strobus L.	white pine	12	1
sylvestris L.	Scotch pine	12	1

Scientific name	Common name	Page	Table
Pinus Continued			
taeda L.	loblolly pine	12	1
thunbergii Parl.	Japanese black pine	13	1
virginiana Mill.	Virginia pine	13	1
Plantago			
lanceolata L.	buckhorn plantain	37	5
Platanus			
occidentalis L.	American sycamore	13	1
Poa			
bulbosa L.	bulbous bluegrass	——	3
compressa L.	Canada bluegrass	——	3
pratensis L.	Kentucky bluegrass	——	3
Polygonum			
cuspidatum Sieb. & Zucc.	Japanese fleeceflower	37	5
cuspidatum v. compactum Sieb. & Zucc.	dwarf Japanese fleeceflower	38	5
persicaria L.	spotted ladysthumb	——	5
Populus			
canescens Sm.	curly poplar	——	1
deltoides Bartr.	eastern cottonwood	13	1
grandidentata Michx.	bigtooth aspen	13	——
robusta (*P. nigra* x *P. agulata* Ait.) C. K. Schneid.	hybrid poplar	——	1
sargentii Dode	plains cottonwood	——	1
x Norway	hybrid cottonwood	——	1
x Siouxland	Siouxland cottonwood	——	1
spp.	cottonwoods	13	1
tremuloides Michx.	quaking aspen	13	——
Prinsepia			
sinensis D. Oliver ex Bean	cherry prinsep	——	2
Prunus			
besseyi Bailey	western sand cherry	——	2
serotina Ehrh.	black cherry	13	1
spinosa L.	blackthorn sloe	——	2
Pseudotsuga			
menziesii (Mirb.) Franco	Douglas-fir	——	1
Pueraria			
lobata Mill.	kudzu	19	2
Quercus			
acutissima Carruthers	sawtooth oak	14	1
falcata Michx.	southern red oak	——	1
macrocarpa Michx.	bur oak	——	1
palustris Muenchh.	pin oak	——	1
pumila Walt.	'Ware' runner oak	——	2
robur L.	English oak	——	1
rubra L.	northern red oak	14	1
Rhamnus			
cathartica L.	European buckthorn	——	2
Rhododendron			
maximum L.	rosebay rhododendron	——	2
Rhus			
aromatica Ait.	fragrant sumac	20	2
copallina L.	shining sumac	20	2
glabra L.	smooth sumac	20	2
typhina L.	staghorn sumac	20	2
Robinia			
fertilis Ashe.	'Arnot' bristly locust	20	2
pseudoacacia L.	black locust	14	1
pseudoacacia L.	black locust (dominant stem)	——	1
Rosa			
multiflora Thunb.	multiflora rose	21	2
rugosa Thunb.	rugosa rose	——	2
virginiana Mill.	Virginia rose	——	2
wichuraiana Crep.	memorial rose	21	2

Scientific name	Common name	Page	Table
Rubus			
allegheniensis Porter	wild blackberry	22	2
hispidus L.	dewberry	22	2
occidentalis L.	wild raspberry	——	2
parviflorus Nutt.	trailing raspberry	22	2
pungens Cambess.	trailing raspberry	22	2
Rumex			
acetosella L.	red sorrel	38	5
Salix			
interior Rowlee.	sandbar willow	——	2
purpurea L.	purpleosier willow	22	2
purpurea var. gracilis Anderss.	slender willow	——	2
purpurea var. nana	dwarf willow	——	2
Sanguisorba			
minor Scop.	salad burnet	38	5
Saponaria			
officinalis L.	bouncing bet	38	5
Setaria			
spp.	millet; bristlegrass	——	3
Shepherdia			
argentea (Pursh.) Nutt.	russet buffaloberry	22	2
Sorbus			
alnifolia (Sieb. & Zucc.) C. Koch	alternate leaf mountain-ash	——	1
Sorghastrum			
nutans Nash	indiangrass	31	3
Spiraea			
tomentosa L.	hardhack	——	2
Stellaria			
spp.	chickweed	38	5
Symphoricarpos			
orbiculatus Moench.	coralberry	——	2
Tamarix			
parviflora DC.	tamarisk	——	2
Taxodium			
distichum (L.) Rich.	baldcypress	——	1
Tilia			
americana L.	American basswood	——	1
Tridens			
flavus (L.) Hitchc.	purpletop	31	3
Trifolium			
alexandrinum Bory. & Chaub.	berseem or Egyptian clover	——	4
fragiferum L.	strawberry clover	——	4
hirtum All.	rose clover	——	4
hybridum L.	alsike clover	——	4
medium L.	zigzag clover	——	4
pratense L.	red clover	——	4
repens L.	ladino clover	——	4
Tripsacum			
dactyloides (L.) L.	eastern gamagrass	32	3
Tussilago			
farfara L.	coltsfoot	38	5
Ulmus			
pumila L.	Siberian elm	——	1
Vaccinium			
spp.	blueberry	——	2
Viburnum			
dentatum L.	arrowwood	22	2
plicatum var. tomentosum Thunb.	doublefile viburnum	22	2
trilobum Marsh.	American cranberrybush	22	2
Vicia			
cracca L.	bird vetch	——	4

Scientific name	Common name	Page	Table
Vitis			
riparia Michx.	riverbank grape	——	2
rotundifolia Michx.	muscadine grape	——	2
spp.	grape	——	2
vulpina L.	frost grape	——	2

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